2018
ANNUAL REPORT
OF THE
CORNELL BIOLOGICAL FIELD STATION

College of Agriculture and Life Sciences
Department of Natural Resources
Cornell Biological Field Station
at Shackelton Point
CORNELL BIOLOGICAL FIELD STATION

ADVISORY COMMITTEE

Director: Lars Rudstam
Facilities Coordinator: Brian Young

Associate Director: Randy Jackson
Station Manager: JoAnne Getchonis

Chair:
Pat Sullivan
Chair and Professor, Department of Natural Resources

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Katherine Bunting-Howarth
Associate Director, New York Sea Grant Institute
Assistant Director, Cornell Cooperative Extension

Paul Curtis
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Frank H. T. Rhodes Professor of Environmental Science,
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Cornell University, and Professor, Ecology and Evolutionary Biology

Peter Paradise
Assistant Dean of Capital Projects and Facilities, College of Agriculture
and Life Sciences at Cornell University

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Extension Leader and Associate Professor, Department of Natural
Resources

Richard Stedman
Professor, Department of Natural Resources; Leader, Cornell
Human Dimensions Research Unit

External:
John Farrell
Director, Thousand Islands Biological Station, Associate Professor,
Department of Environmental and Forest Biology, SUNY College of
Environmental Science and Forestry at Syracuse

Brian Lantry
Director, USGS Great Lakes Lake Ontario Unit.

Steve Hurst
Fisheries Chief, NYS Department of Environmental Conservation
Our Oneida Lake and Great Lakes research programs are thriving including continuation of the long-term warmwater grant on Oneida Lake fisheries and the Great Lakes National Program Office grant on all five Great Lakes. We also completed a number of projects and added a couple of new ones. We increased our technical staff (Patrick Boynton, Jacob VanDeValk, and Sarah Schaefer), had a record number of senior honors thesis students finishing (congratulations Kayden, Audrey, Jackie, Iman, Sophie, and Shujuan), 11 summer interns, started new graduate students (Taylor Brown, Joe Connolly) and a new postdoc (Tom Evans), and welcomed a visiting scientist (Cuicui Qi) to CBFS. Among all this activity, we also helped organize two international conferences on large lakes: one in Irkutsk by the shores of Lake Baikal, Russia, and one in Evian, by the shores of Lake Geneva, France, and finished a special issue on Great Lakes in the Journal of Great Lakes Research. More details below in our report on the 62nd year of operations of the Cornell Biological Field Station at Shackelton Point.

This year was a great year for recognition of CBFS science. Annie Scofield, with coauthors Watkins, Weidel, Luckey and Rudstam, received the Chandler-Misener award of the International Association for Great Lakes Research for the Best Paper in the Journal of Great Lakes Research. Her paper on the deep chlorophyll layer in Lake Ontario showed the importance of this deep algae layer, its constituent algae groups, and what triggers its formation in June and dissipation in September. Deep chlorophyll layers need to be considered when evaluating ecological changes in the Great Lakes. Tiffany Vidal, with coauthors Irwin, Wagner, Rudstam, Jackson and Bence, received the Robert Kendall award of the American Fisheries Society for the Best Paper in the Transactions of the American Fisheries Society. Tiffany, a graduate student with Brian Irwin and now working in Massachusetts, analyzed the long-term gillnet data on walleye in Oneida Lake and developed a new method to analyze data which allowed for detection of perturbations in the data set using both means and variances. This paper shows the importance of long-term data for understanding change and how to get the most of that data. Both papers were published in 2017. It is the first time I have been part of receiving a best paper award in a journal. In addition, two CBFS publications were selected for special compilations in 2018, John Forney’s 1974 article was included in the AFS book Foundations in Fisheries Science, and Brent Boscarno’s 2007 article was selected for ASLO compilations of influential papers about large lakes of the world. I also want to congratulate Annie Scofield, who completed her PhD last summer and is now a postdoc at Purdue, and James Watkins who was promoted to Senior Research Associate and became a full member of the graduate faculty of Cornell’s Natural Resource field.

We had many visitors during the summer of 2018, including John Lyons from Madison, Wisconsin, Mike Sierszen from Duluth, Minnesota, Bart DeStasio from Lawrence, Wisconsin, Sasha Karatayev and Lyuba Burlakova from Buffalo, Rosaura Chapina from Burlington, Vermont, Kay vanDamme from Frankfurt, Germany, Pat Hudson and Patty Armanio from Ann Arbor Michigan, Kelly Bowen, Sarah Bailey and Marten Koops from Burlington Ontario (Canada), Yushun Chen from the Chinese Science Academy in Wuhan, and participants in four workshops. Rebecca Schneider, Karim Kassam, Nelson Hairston, Roxanne Razavi, and Paul Curtis continued working at the station. They brought in new Cornell students to work at CBFS, Sol Lisboa with Rebecca and Leo Louis with Karim.

Thanks to all of you that contributed to another successful CBFS year.
**CBFS STAFF AND STUDENTS**

**Senior Scientists**
Lars Rudstam (Director, aquatic ecology)
Randy Jackson (Associate Director, fisheries)
James Watkins (Senior Research Associate, Great Lakes program coordinator)

**Administration and Buildings**
JoAnne Getchonis (Station Manager, Education/Outreach Coordinator)
Brian Young (Facilities Coordinator)
Pete Kite (Maintenance Mechanic)
Dustin Darnell (Director of Facilities, Agriculture Experiment Station)

**Research Support Specialists**
Tom Brooking (Fisheries)
Kristen Holeck (Limnology, Great Lakes ecology)
Tony VanDeValk (Fisheries)

**Technicians**
Patrick Boynton (Great Lakes ecology)
Joe Connolly (Great Lakes ecology)
Gabriella Doud (Great Lakes ecology)
Christopher Hotaling (Limnology)
Christopher Marshall (Great Lakes ecology)
Sarah Schaeffer (Great Lakes ecology)
Jacob VanDeValk (Angler survey)
Beth Whitmore (Great Lakes ecology)

**Education Coordinator**
David White (New York Sea Grant)

**Visiting Scientists/Postdocs**
Cuicui Qi (visiting from Hefei City, Anhui Province, China)
Thomas Evans (Postdoc, Great Lakes)

**Professor Emeriti**
John Forney (Fish ecology)
David Green (Fisheries)
Ed Mills (Limnology)

**Cornell Graduate Students**
Kalia Bistolas (PhD, Microbiology, Hewson/Rudstam): *Ecological effects of amphipod viruses*
Joe Connolly (MSc, Natural Resources, Watkins/Rudstam): *Zooplankton*
Taylor Brown (MSc/PhD, Natural Resources, Sethi/Rudstam): *Cisco ecology in Lake Ontario*
Martin Feehan (PhD, Natural Resources, Curtis): *Wildlife management*
Ellen George (PhD, Natural Resources, Rudstam/Hare): *Cisco ecology in the Great Lakes*
Toby Holda (PhD, Natural Resources, Rudstam/Watkins): *Ecology of Mysis diluviana*
Sol Lisboa (PhD, BEE, Walter/Schneider): *Groundwater-lake interactions*
Leo Louis (MSc, Natural Resources, Kassam): *Ecological calendars*
Matt Paufve (MSc, Natural Resources, Sethi/Rudstam): *Cisco rehabilitation*
Lyndsie Schaffner (MSc, EEB, Hairston): *Clonal evolution in Daphnia*
Annie Scofield (PhD, Natural Resources, Rudstam): *Great Lakes ecology* (Completed in 2018)

CBFS and Oneida/Great Lakes data are also used by graduate students from other universities, including Tiffany Vidal from University of Georgia (with Brian Irwin), Rosaura Chapina, Allison Hrycik and Brian O’Malley from University of Vermont (with Jason Stockwell), and Iman Pakzad from SUNY-ESF (with Roxanne Razavi).
Interns at CBFS during the summer of 2018 were involved in a number of research projects addressing current ecological concerns. Funding for our intern program in 2018 came from the Great Lakes National Program Office grant, NYSDEC Warmwater grant, the John and Janet Forney Foundation, and the Doris Duke Foundation. The interns presented their findings in August as part of the CBFS Summer Seminar program at Shackelton Point and in December at the Department of Natural Resources Undergraduate Research Symposium. A special thanks to the intern advisors without whom this program would not exist – in 2018 they were Tom Brooking, JoAnne Getchonis, Kristen Holeck, Toby Holda, Chris Hotaling, Randy Jackson, Sol Lisboa, Lars Rudstam, Tony VanDeValk, Jim Watkins, Paul Curtis, Rebecca Schneider, and Karim Kassam.

**Dominique Agnew**, Class of 2021 (Research Advisors: L Rudstam, K Holeck)
Major: Environmental and Sustainability Sciences
*Nearshore macrophyte survey in Oneida Lake*

**Allison Croak**, Class of 2021 (Research Advisors: J Watkins, T Holda)
Major: Biology
*Using ponar videos to measure mysid densities*

**Jenna Diehl**, Class of 2018-December (Research Advisor: P Curtis)
Major: Biology, Pennsylvania State University
*The common tern (Sterna hirundo) at Oneida Lake*

**Iriel Edwards**, Class of 2020 (Research Advisors: R Jackson, K Kassam)
Major: Environmental and Sustainability Sciences; Entomology
*The contribution of country foods to food security in the Oneida Lake watershed*

**Vivian Garcia**, Class of 2020 (Research Advisors: S Lisboa, R Schneider)
Major: Environmental and Sustainability Sciences
*Groundwater flow and benthic algae*

**Arjun Hausner**, Class of 2020 (Research Advisors: K Holeck, L Rudstam, C Hotaling)
Major: Earth and Atmospheric Sciences; Environmental and Sustainability Sciences
*The dynamics of Oneida Lake cyanobacteria: understanding their source, behavior, and nutrient limitations*

**Tram La**, Class of 2021 (Research Advisors: J Watkins, T Holda)
Major: Computer Science
*Effect of net size and light on Mysis diluviana catches in Ontario and the Finger Lakes*

**Tia Offner**, Class of 2020 (Research Advisors: R Jackson, T Brooking)
Major: Ecology and Evolutionary Biology
*Using underwater video to survey round goby, Neogobius melanostomus, in Oneida Lake*

**Colton Poore**, Class of 2020 (Research Advisor: J Getchonis)
Major: Biology, English
*The impact of algal blooms on shoreline businesses, lakefront homeowners and recreational lake visitors on a large inland lake*

**Emma Railey**, Class of 2020 (Research Advisors: L Rudstam, K Holeck)
Major: Environmental and Sustainability Sciences
*Dreissenid dynamics in Oneida and Onondaga Lakes: inferences from nearshore to offshore transects*

**Audrey Stanton**, Class of 2018-December (Research Advisor: J Getchonis)
Major: Environmental and Sustainability Sciences
*Long-term data set on Biological Field Station undergraduate interns*
CBFS provides a center for ecological research on aquatic ecosystems, and strives to provide an exciting, inviting, and collegial working and learning environment. CBFS faculty and staff collaborate with a large number of investigators in the US, Canada, and other countries. Our collaborators are very important to our program. The following individuals were involved in various aspects of the program (research, teaching, extension, administration in 2018):

**Cornell University:**
*Department of Natural Resources:* Paul Curtis, Angela Fuller, Matt Hare, Karim Kassam, Steve Morreale, Rebecca Schneider, Suresh Sethi, Patrick Sullivan  
*Department of Ecology and Environmental Biology:* Nelson Hairston, David Lodge, Amy McCune, Paul Simonin, Lyndsie Schaffner  
*Department of Microbiology:* Ian Hewson  
*Biological and Environmental Engineering:* Todd Walter  
*College of Veterinary Medicine:* Rod Getchell  
*Cornell Cooperative Extension/ New York Sea Grant:* Kathy Bunting-Howarth, Helen Domske, Jesse Lepak, David White  
*Mann Library:* Erica Johns

**SUNY Colleges and Universities:**
*SUNY College of Environmental Science and Forestry:* Greg Boyer, John Farrell, Karin Limburg, Kim Schulz, Don Stewart, Roxanne Razavi  
*SUNY Buffalo:* Joe Atkinson  
*SUNY Buffalo State College:* Lyuba Burlakova, Alexander Karatayev, Susan Daniels, Knut Mehler  
*SUNY- New Paltz:* David Richardson  
*SUNY Brockport:* Joe Makarewicz, Jacques Rinchard

**US Universities:**
*Central Michigan University:* Hunter Carrick  
*Hobart and William Smith College:* Lisa Cleckner  
*Hartford College:* Bin Zhu  
*Florida State College:* Christopher Perle  
*Miami University, Ohio:* Craig Williamson, Mike Vanni  
*Michigan State University:* Pat Soranno, Jim Bence  
*Lawrence University, Wisconsin:* Bart DeStasio  
*The Ohio State University:* Stuart Ludsin, Rebecca Dillon, Lyndsie Collis, Jim Hood  
*Purdue University:* Thomas Höök, Paris Collingsworth, Annie Scofield  
*University of Georgia:* Brian Irwin, Tiffany Vidal  
*University of Michigan:* David Jude, Tom Johengen, Hongyang Zhang  
*University of Minnesota Duluth:* Euan Reavie, Kitty Kennedy, Andrew Bramburger, Katya Kovalenko  
*University of Notre Dame:* Michael Pfrender  
*University of Vermont-Burlington:* Donna Parrish, Jason Stockwell, Allison Hrycik, Brian O’Malley, Rosaura Chapini, Jonathan Doubek  
*University of Wisconsin-Madison:* Paul Hanson, Corinna Gries, Sarah Collins

Cisco workshop participants
University of Wisconsin-Superior: Mary Balcer
Virginia Tech: Kelly Cobourn, Cayelan Carey, Kevin Boyle, Michael Sorrice, Amy Hetherington

Canadian Universities and Institutions:
Department of Fisheries and Oceans, Canada: Kelly Bowen, Warren Currie, Marten Koops, Mohi Munawar
Ontario Ministry of Natural Resources: Tim Johnson, Tom Stewart, Jeremy Holden, Jake LaRose, Brent Metcalf
Ontario Ministry of the Environment: Todd Howell
University of Windsor: Aaron Fisk
University of Guelph: Paul Hebert

International Universities and Institutions:
Anhui Agricultural University, China: Xueying Mei
Jinan University, China: Xiufeng Zhang
University of Western Australia: Matt Hipsey, Louise Bruce
University of Stockholm, Sweden: Sture Hansson
Swedish Agriculture University: Rahmat Naddaf
Mistra, Sweden: Biljana Macura
Umeå University, Sweden: Pär Byström
Belarus University: Boris Adamovich, Hanna Zhukava, Tatayna Zhukova, Tamara Mikheyeva
University of Bologna, Italy: Laura Airoldi
University of Groningen, Netherlands: Klemens Eriksson
Technical University of Denmark: Josianne Støttrup
Czech Academy of Sciences: Jan Kubecka, Milan Riha
French National Institute for Agricultural Research: Orlane Anneville
University of Geneva, Switzerland: Bas Ibelings
University of Konstanz, Germany: Dietmar Straile
Fisheireforschung Lagenargen, Lake Constance: Roland Rösch, Alexander Brinkner, Ziga Ogorelec
EAWAG, Zurich, Switzerland: Piet Spaak, Linda Hatliner
Senckenberg Research Institute, Frankfurt, Germany: Kay Van Damme

Local, State and Federal Agencies:
NYS Canal Corporation: Peter Pazer
NYS DEC-Albany: Lisa Holst, Steve Hurst, Shaun Keeler, Jeff Loukmas, Doug Stang, Leslie Surprenant, Don Zelazny
NYS DEC-Region 8: Brad Hammers, Web Pearsall, Matt Sanderson
NYS DEC-Region 7: Dan Bishop, David Lemon, Scott Prindle
NYS DEC-Region 6: Doug Carlson, Frank Flack, Roger Klindt, Russ McCullough, Michael Wilkinson
NYS DEC-Lake Ontario Unit: Michael Conerton, Jana Lantry, Steven LaPan, Chris Legard
NYS DEC-Lake Erie Unit: Don Einhouse, James Markham
NYS OPRHP - Central Region: Tom Hughes
EPA-Region 2: Fred Luckey
EPA-Duluth: Joel Hoffman, Anett Trebitz, Tom Hollenhorst
EPA – GLNPO: Eric Osantowski, Todd Nettesheim, Elizabeth Hinchey-Malloy, Lou Bloome
NOAA-Great Lakes Laboratory: Doran Mason, Ed Rutherford, Ashley Elgin, Hank Vanderploeg
Michigan DNR: Jory Jonas, Pat O’Neill
Onondaga County: Chris Gandino, Janaki Suryadevara
USFWS: Scott Schlueter, Curt Karboski, Zy Biesinger, Dimitry Gorsky
USGS-Great Lakes Science Center, Ann Arbor, MI: Bo Bunnell, Ed Roseman, Wendylee Stott, David Warner, Yu-Chun Kao, Robin DeBruyne, Patricia Armenio, Patrick Hudson
USGS-Great Lakes Laboratory, Oswego, NY: Brian Lantry, Brian Weidel, Brian O’Malley
USGS-Tunison, Cortland, NY: Jim McKenna
USGS-Great Lakes Science Center Erie: Patrick Kocovsky
USGS – Great Lakes Science Center Superior: Dan Yule
Vermont Fish and Wildlife: Bernie Pientka
Wisconsin DNR: Willie Fetzer, Zacharias Feiner

Non-Government Organizations and Private Consulting Firms:
CSRA: Richard Barbiero, Barry Lesht
Cooper Environmental: John Cooper
Ecologic: Elizabeth Moran
The Nature Conservancy: Darran Crabtree, Mathew Levine, Matt Herbert
Upstate Freshwater Institute: Dave Matthews, Dave O’Donnell, Sue O’Donnell, Feng Peng
LimnoTech, Michigan: John Lenters
Virginia Museum of Natural History: Jennifer Reid

2018 CBFS Summer Seminar Series

Annie Scofield, PhD Candidate, Department of Natural Resources, Cornell University
“Diving deeper: Drivers of chlorophyll and plankton distributions in the Laurentian Great Lakes”

Bart De Stasio, Professor, Biological Sciences, Lawrence University
“Unexpected changes in the Green Bay, Lake Michigan lower food web following biological invasions and nutrient reductions”

Randy Jackson, Associate Director, Cornell Biological Field Station, Department of Natural Resources, Cornell University
“Oneida Lake as a melting pot: the impact of invasive species on historic and modern fisheries”

Mike Sierszen, Senior Scientist, EPA-Duluth. “How large lake food webs are supposed to work, I think”

Alexander Karatayev, Director and Professor, Great Lakes Center, SUNY Buffalo State
“Can introduced species replace lost biodiversity? A test with freshwater molluscs”

J Connolly, T Holda, C Marshall, L Rudstam, J Watkins, B Whitmore, Cornell Biological Field Station
“Great Lakes projects updates: speed talks from CBFS staff and students”

John Lyons, Senior Scientist, Wisconsin Department of Natural Resources; Adjunct Professor University of Wisconsin Madison
“Projected changes in the distribution of stream fishes in the Great Lakes Region in response to climate change”

Roxanne Razavi, Assistant Professor, Environmental and Forest Biology, SUNY ESF
“Effect of the Round Goby invasion on fish mercury bioaccumulation in the Oneida Lake food web”

2018 Workshops at CBFS

Four workshops were organized by CBFS during 2018:

The workshop “Identifying Research Priorities for Cisco in Lake Ontario” was held on May 31 at CBFS, organized by Ellen George, Matt Hare and Lars Rudstam from Cornell, Jesse Lepak from Sea Grant, and Darran Crabtree from The Nature Conservancy. Over 30 attendees from a variety of state and federal agencies, universities, and conservation organizations were present. The goals of the workshop were to review the current knowledge of cisco ecology, summarize recently completed and ongoing research efforts, and to identify key research priorities to support cisco restoration in Lake Ontario. The outcomes of the workshop are presented in a summary report (George et al. 2018).
A workshop on the connection between lake productivity and fisheries production was organized by Marten Koops (DFO) with Rudstam, Jackson and Watkins in November 2018. This workshop had participants from Canada DFO and OMNRF, as well as NOAA-GLERL. Discussions centered on the coupling between phosphorus loading and fisheries in the Great Lakes and includes Oneida Lake as one of the main study lakes due to the long term data available from our lake. This workshop was part of the Great Lakes Fisheries Commission funded project (Koops and others including Rudstam and Jackson) described under research activities.

The barcoding and biomonitoring projects for the Great Lakes organized two workshops on zooplankton taxonomy at CBFS. The first workshop focused on cladocerans on May 29-June 1, 2018 and was led by global taxonomy expert Kay Van Damme of Senckenberg Institute. A second zooplankton taxonomy workshop October 22-25, 2018 was led by Patrick Hudson of USGS-Ann Arbor and included our six resident taxonomists, Heidi Schaefer from University of Wisconsin Superior, and Lyndsie Collis of Ohio State University.

2018 CBFS PROGRAM HIGHLIGHTS

Oneida Lake and other Inland Lakes

A major research program at CBFS is the Oneida Lake projects involving two of CBFS’ senior scientists: Jackson concentrating on fish and fisheries and Rudstam concentrating on lower trophic levels. Paul Curtis continued his work on colonial waterbirds in the lake, Rebecca Schneider studied ground water phosphorus input with a new PhD student Sol Lisboa, Roxanne Razavi worked with mercury contamination in sport fish as affected by round goby, Amy Hetherington completed her work on mussel dynamics, and Karim Kassam with graduate student Leo Louis worked on the ecological calendar. The Oneida program involves the research staff Brooking, VanDeValk, Holeck, and Hotaling, and summer interns. Oneida Lake is a site member of the Global Lakes Ecological Observatory Network (GLEON) and part of several research projects comparing data from lakes across the world. Oneida Lake is also one of three lakes studied in an NSF project in the Coupled Human and Natural Systems program area (Pls Carrey, Cobour and Boyle, Virginia Tech). The Oneida Lake fisheries data was analyzed by research groups in the USGS Coop Unit in Georgia (Irwin), the University of Pennsylvania (Wagner), USGS (Bunnell and Kao) and DFO Canada (Hossain and Koops). In addition, Nelson Hairston and Lindsay Schaffner are wrapping up a study on rapid clonal evolution in Daphnia. Work on other inland lakes include studies of alewife and zooplankton on Silver Lake, PA, and on alewife, mussels, zooplankton and phytoplankton in Onondaga Lake.

Ongoing project: Long-term studies of Oneida Lake

Randy Jackson, Tom Brooking, Tony VanDeValk, Lars Rudstam, Kristen Holeck, Chris Hotaling, John Forney (Funded by NYS DEC)

Our studies of the fisheries and limnology of Oneida Lake were initiated in the mid-1950s as an assessment of the status of the lake’s important walleye and yellow perch fisheries. The program has enjoyed continuous funding from the New York State Department of Environmental Conservation (NYSDEC), and for over 40 years has included annual monitoring of multiple trophic levels and physical conditions, representing a true ecosystem approach to understanding the dynamics of the lake’s fish community and fisheries. Ongoing studies on Oneida Lake include detailed studies of walleye and yellow
perch from larval to adult life stages, assessment of offshore and inshore fish community composition and monitoring of nutrients, primary and secondary production, as well as annual creel surveys. While maintaining the continuous data set started by John Forney, we have increased the scope of our studies, which now include intensive sampling of the lake’s nearshore fish community and annual creel surveys. Oneida Lake is the State’s second most heavily fished lake, and data collected by Field Station staff provide timely information to DEC managers to ensure sustainable fishing opportunities, particularly for walleye, yellow perch and smallmouth bass. The data series has also allowed important insights into the response of lake ecosystems to perturbations such as exotic species and climate change. We have already documented fundamental shifts in fish community composition resulting from increases in water clarity associated with zebra mussels, and are currently assessing the impacts of displacement of zebra mussels by quagga mussels. The double-crested cormorant had profound impacts on walleye and yellow perch, and our studies of these impacts have informed cormorant management throughout their range. Analyses of the response of walleye and yellow perch to cormorant management are shedding light on the relative importance of that management and concurrent restrictions of walleye harvest. Warming water temperatures may be contributing to increased production of largemouth and smallmouth bass, gizzard shad and other species near the northern extent of their range. Sampling in 2014 revealed that the round goby has finally become established in the lake, although densities were low. By late summer of 2015, gobies were the most abundant species in our trawl samples and gobies continued to be abundant in 2016. There is evidence that there was a die off of round goby during the winter of 2016-17, but enough remained to reproduce successfully and fall catches of young goby in 2017 were comparable to previous years. Gobies continued to be common in many sampling gears in 2018, though not at the abundances observed in 2016. Gobies appeared in the diets of most of our more common fish species and were also foraged upon by cormorants. In 2018, we continued targeted sampling of common predators to assess the importance of gobies in predator diets. Consistent with evidence of reduced goby numbers, gobies were not as common in predator diets in 2018 as 2016, but were still used by all sport fish. We observed marked declines in angler success in 2016, which is most likely related to the abundant new prey resource represented by gobies, but angler catches improved in 2017 and 2018 when goby densities were reduced, further supporting the potential for gobies to affect angler catch rates. We will have an excellent opportunity to continue assessing the impacts of this new invasive on the lake’s fish and fisheries in the upcoming years. Walleye continue to be the most popular sport fish in Oneida Lake. Bass are also a popular fishery, and almost 30% of the anglers interviewed during our June/July creel survey were targeting bass, another sign of change from the days when walleye anglers comprised most of the lake users. As Oneida Lake has changed, so too has the fish community and the fishery, and our studies continue to expand our efforts to understand the dynamics of this economically important resource.

**Ongoing project: Common terns on Oneida Lake**

*Paul Curtis, Martin Feehan, Jenna Diehl (Funded by NYS DEC)*

The long-term studies on the colonial waterbirds on Oneida Lake, initiated in the 1970s, continued during 2018. Investigators Paul Curtis and Martin Feehan worked with intern Jenna Diehl from Penn State University to monitor the nesting activity of Common Terns on Little Island. Breeding success for Common Terns at Oneida Lake was about average during the 2018 field season. The peak count was 369 tern nests on July 3rd at Little Island. We banded 457 total chicks during the 2018 field season, and 22 banded chicks were later found dead, to give maximum chick survival rate of 95.2%. A total of 27 banded
adult terns were recaptured at their nests, ranging in age from 2-18 years (mode = 6 years). Two foreign-banded terns were caught; one was originally banded in Buffalo, New York, and the other Ogdensburg, New York. Studies of nocturnal sleep behavior of incubating common terns occurred on both Little Island (Oneida Lake), and Gull Island (Presqu’ile Provincial Park, ON), to describe the sleep under different levels of predation. With no observed predators on Little Island, preliminary analyses showed the terns slept much more soundly than in Presqu’ile Provincial Park, where gulls and herons share their nesting island. On Little Island, we again installed a gull-exclusion wire grid, and removed 13 ring-billed gull nests, preserving the nesting space only for common terns. This year we also completed a study of tern migration to determine where birds nesting on Oneida Lake are migrating and overwintering. We recaptured the last observed tern marked with a geolocator (small tracking devices that record bird location using daylight sensors). A collaborative manuscript describing tern migration was published in *The Auk* along with other northeastern avian scientists.

**Ongoing Project: Silver Lake**  
*Jim Watkins, Beth Whitmore (Funded by the Rose Conservancy and the Actus Foundation)*

In 2018 we expanded our limnological monitoring of Silver Lake in northern Pennsylvania to two other regional lakes including Pops Hobby Lake and Tripp Lake. Monthly sampling tracked changes in stratification, water clarity and chemistry, and phytoplankton/zooplankton populations. All three lakes experienced blue-green algae blooms in late summer/fall.

**Ongoing project: Food web changes in Onondaga Lake**  
*Lars Rudstam, Chris Hotaling, Dave Matthews, Chris Gandino, Janaki Suryadevara (Funded by Onondaga County, NY)*

CBFS is involved with analysis of lower trophic levels, including phytoplankton, zooplankton and dreissenid mussels in Onondaga Lake, a valuable resource for the city of Syracuse. We conduct a survey of the alewife population each year- in 2018 this survey was in June and showed continued high alewife abundance in the lake. The 2017 data was incorporated in the Ambient Management Plan report produced by Onondaga County in cooperation with Upstate Freshwater Institute and CBFS. Gobies have increased in the lake and mussel abundance, in particular quagga mussels, declined in 2017 and 2018. We are using this data to investigate the relative importance of grazing by zooplankton and mussels in a stratified lake to compare with the same interactions in Oneida Lake. We are also involved with overseeing the sampling program through the Onondaga Lake Technical Advisory Board.

**Ongoing Project: Ecological calendars to anticipate climate change**  
*Karim-Aly Kassam, Madeline Rich, Tamar Law, Leo Louis, Adnan Akyuz (North Dakota State University), Art DeGaetano, Christopher Dunn, Randy Jackson, Amanda Rodewald, Lars Rudstam, Morgan Ruelle, David Wolfe (Funded by the Atkinson Center for a Sustainable Future, Academic Venture Fund)*

This project is developing ecological calendars as a means of building of anticipatory capacity for climate change at the scale of community. Ecological calendars are systems to keep track of time based observation of weather, plants, and animals. Seasonal events – such as the nascence of a flower, the emergence of an insect, the arrival of a migratory bird, the movement of fish, or the breakup of lake ice – may serve as more reliable indicators of seasonal change than counting of days based on the position of the sun, moon, and stars. Indigenous and other place-based ecological knowledge of seasonal indicators has enabled communities to coordinate their activities with the rest of their ecosystems. By integrating
such knowledge with cutting-edge science, the project will develop ecological calendars that anticipate trends and variability resulting from global climate change. This participatory action research project is designed and implemented in partnership with fishing and farming communities in the Oneida Lake Basin, as well as Dakota and Lakota First Nations in the Standing Rock Sioux Reservation of North and South Dakota. During 2016, Tamar Law was based at CBFS and undertook semi-structured interviews. In 2017, Madeline Rich continued this work at CBFS. Ecological calendar research in Oneida Lake and Standing Rock will serve as a proof of concept for similar projects in the rest of the world. In March 2016, the research team received an additional 1.2 million Euros from the Belmont Forum to conduct further research on ecological calendars in the Pamir Mountains of Afghanistan, China, Kyrgyzstan, and Tajikistan in collaboration with Chinese, German, and Italian scholars. In 2018 validation or research findings was undertaken in each community in the Pamir Mountains and at Standing Rock. In 2019, validation of research findings will be undertaken at Lake Oneida. Both projects will culminate in a high-profile international conference focused on the role of ecological calendars in building anticipatory capacity for anthropogenic climate change and variability.

New Project: Food Security

Karim-Aly Kassam, Randy Jackson, Iriel Edwards (Funded by CBFS Summer Fellowship)

This project grew out of the Ecological Calendars Project. In 2018, undergraduate intern, Iriel Edwards, investigated how hunting, fishing, and foraging, create food security within communities in the Oneida Lake watershed through sharing networks. She interviewed 20 local sportsmen and women, mushroom foragers, and those involved in the donation or sale of country foods and products to better understand why people partake in these activities and to what extent. In addition to the interviews, a subsistence survey was distributed through local sportsmen clubs and outdoor groups to assess what wildlife foods are eaten, at what time of the year, and how they are acquired. So far 96 responses have been received. The survey demonstrates that people greatly use these activities to acquire food and a majority of participants share the country food they acquire with their friends, family, and members of the community.

Ongoing Project: Daphnia eco-evolutionary process meets the clear water phase: seasonal plankton dynamics when consumers evolve

Nelson Hairston, Lindsay Schaffner, Steve Ellner, Eliza Fairchild, Lars Rudstam (Cornell), Brooks Miner (Ithaca College), Piet Spaak (EAWAG Switzerland), Luc De Meester, Lynn Govaert (KU Leuven, Belgium)

The seasonal change in phytoplankton and Daphnia abundance is a classic pattern in the ecology of temperate zone lakes. It includes a spring bloom dominated by edible diatoms, followed by an increase in grazing Daphnia that terminates the bloom with a clear-water phase dominated by small rapidly-growing phytoplankton, at the end of which the Daphnia population declines and a summer bloom of cyanobacteria and colonial green algae dominates. We show for Daphnia mendotae in Oneida Lake, New York, that the Daphnia population responds evolutionarily to the natural selection imposed by seasonal change in phytoplankton quality. Genetically distinct clones (identified using microsatellite DNA loci) rise to prominence at different times of year consistent with their ability to grow on phytoplankton of different edibility. Clonal performance was determined in the lab by measuring juvenile (somatic) growth rate on “spring phytoplankton” comprised of diatoms, cryptophytes and greens, and on “summer phytoplankton” comprised of cyanobacteria and greens.” Clones that dominated in spring grew much better on spring than on summer phytoplankton, while the one that dominated in summer grew nearly equally well on both food types. Calculations of clonal population growth rates show seasonal changes in fitness differences, and projections of effects of
clonal evolution on total *Daphnia* population growth rate shows the importance of seasonal evolution on lake plankton dynamics. The result is that classic seasonal plankton consumer-resource dynamics in this lake are eco-evolutionary in nature: underlain by consumer evolution which affects those dynamics while they are in progress. Future plans are to study differences in gene expression among clones when exposed to different food types.

**Ongoing Project: Coupled Natural and Human Systems CNHS: Linking land-use decision making, water quality, and lake associations to understand human-natural feedbacks in lake catchments**

*Kelly Cobourn, Cayelan Carey, Kevin Boyle, Amy Hetherington (Virginia Tech) and others including Lars Rudstam and Randy Jackson (Funded by the National Science Foundation (2016-2019); administrated through Virginia Tech)*

Freshwater lakes and their catchments present a rich and fascinating opportunity to examine the dynamics of coupled natural and human systems (CNHS). To identify and quantify feedbacks between lake water quality and human behavior, we are developing a novel, coupled modeling framework that captures how land-use decision making interacts with hydrological and limnological processes to transform nutrient loads into changes in lake water quality, and how altered water quality feeds back to human systems by affecting the amenities that people value. Our coupled modeling framework will integrate key human and natural systems in three focal lake catchments, allowing us to investigate human-natural feedbacks in those catchments and to build on our understanding of those linkages to generate insight into CNHS at a broad scale. Our interdisciplinary team of scientists and community partners seeks to comprehensively investigate the flows, nature, and extent of linkages among human and natural systems in three focal lake catchments, Oneida Lake, Lake Sunapee in New Hampshire and Lake Mendota in Wisconsin. Models of lake dynamics, watershed nutrient influx, crop dynamics, economics of crop choice selection, property price dependency on lake characteristics, and analysis of social interactions are proceeding and a conceptual paper have been published in 2018.

**New Project: Hg dynamics in fish around New York State following the invasion of round goby.**

*Suresh Sethi, Lisa Cleckner, Roxanne Razavi, Randy Jackson, Lars Rudstam (Funded by NY Water Resources Institute)*

The invasive fish round goby (*Neogobious melanostomus*) is rapidly expanding across New York inland waterbodies and is rapidly moving towards the densely populated Hudson River system. After being recorded in Lake Erie and Lake Ontario in the early 1990s, they have since spread through the Erie Canal to Cross Lake, Onondaga Lake, Oneida Lake, Cayuga Lake, and possibly Seneca Lake (anecdotal evidence). Where introduced, round goby quickly reach high biomass with densities of up to 70 fish/m² observed in Cayuga Lake by 2016. As an abundant new ecosystem component, round goby enter the foodweb and their impact on contaminants cycling has become an important management concern related to fish consumption. As predators, round goby foraging behavior potentially exposes them to high contaminant loads, consuming benthic invertebrates and filter feeding invasive mussels. As prey, goby have been recorded in stomachs of almost all resident gamefish in invaded waterbodies. Presently, the potential for goby to impact predatory gamefish contaminant loads either through biomagnification, or possibly through growth dilution, is not known. Here, we seek to fill that knowledge gap by providing information on both round goby and top predator contaminant loads pre- and post-goby invasions. Building from existing contaminants data hosted by the NY State which provide a pre-goby baseline, our objectives are to test round goby and predatory gamefish
for mercury and organochloride contaminants across a range of invaded systems at the invasion front. By examining goby and predator contaminants pre and post invasion across a range of lakes with varying environmental contaminant loads, we will be able to inform lake managers about anticipated contaminant responses in gamefish, providing data needed to inform NY fish consumption advisories as the invader moves across the landscape.

**New Project: HABS disruption with sound and fish effects.**  
*Lars Rudstam, Rod Getchell (Funded by New York State)*

The purpose of this study is to gather the data necessary to determine if the use of ultrasonic algal control devices in New York waters will cause unreasonable harm to resident fish species. Considering New York invests millions of dollars annually to provide world class fishing opportunities to residents and visitors, it is critical that we determine the impacts, if any, the statewide application of this technology will have on recreational and ecologically important fish species. This project with Cornell will provide the data necessary to determine if: (1) the frequency of the ultrasonic control devises results in harmful histological and morphological effects on species of recreationally and ecologically important fish species; and (2) The application of ultrasonic control devices elicits a behavioral response of recreationally and ecologically important fish species.

**Comparisons of Oneida Lake across North America and the World**

Oneida Lake is known for the available long-term data. But it is only one lake and we rely on comparisons of our data sets with lakes around the nation and around the world to deduce general trends. Many of the projects are through the Global Lakes Ecological Observatory Network (GLEON). As a site member of GLEON, CBFŞ are partners in several projects that benefit from comparative approaches to limnology and lake – watershed interactions. Additional projects have developed through the interests of the scientific community in the Oneida data independent of GLEON, examples are the mussel project and the inland fish production project. Most of the projects listed under this heading are administrated by other agencies or universities than Cornell. They do provide important insights into the structure and function of lake ecosystems and we are proud to be part of these internationally collaborative projects. We are pleased that our many years of efforts on collecting long-term data on Oneida Lake are being used by others across the globe. To facilitate these interactions, we have made 10 datasets available (walleye, yellow perch, gillnet catches, trawl catches, limnology, phytoplankton, zooplankton, benthic invertebrates, ice cover, dreissenid mussels) on the DataONE data archiving system and update these data sets each year.

**New GLEON Project: Top-down versus Bottom-up controls on aquatic food webs**  
*Taylor Leach, Amber Rock, Annie Scofield, and other GLEON collaborators*

This project aims to better understand the relative importance of top-down and bottom-up forces on aquatic food web structure in lakes and ponds. We are in initial stages of the project and are in the process of compiling data sources with data for three or more trophic levels over a 10-year period of monitoring. We have the primary questions:

1) What is the relative importance of top-down vs. bottom-up control of food webs?
2) What lake characteristics explain patterns of top-down vs. bottom-up control?

We seek to improve our knowledge of the conditions under which, and at what trophic levels, we observe differences in food web structuring processes.
Ongoing GLEON Project: Global evaluation of the impacts of storms on freshwater habitat and structure of phytoplankton assemblages
Orlane Anneville (INRA, France), Bas Ibelings (University of Geneva, Switzerland), Jason Stockwell and Jonathan Doubek (University of Vermont), Lars Rudstam and other GLEON collaborators

The GEISHA project relates the effects of physical disturbances and water column stability on plankton communities. This project started in 2015 and received additional funding for 2016-2018 in both the US and France to do comparative analysis of long term data series of phytoplankton, including Oneida Lake, to better understand the effect of storms on phytoplankton community organization. Oneida Lake is one of 8 lakes with the most detailed analysis possible and results were presented in France and Australia meetings in 2018.

Ongoing GLEON Project: Importance of the timing of spring runoff to summer production in lakes
Allison Hrycik, Jason Stockwell (University of Vermont), Lars Rudstam and other GLEON collaborators

The research question tested in this project is “changes in the timing of spring runoff, specifically more runoff occurring in the winter and early spring, will lead to reduced productivity and phytoplankton biomass during the summer stratified period”. Data sets have been assembled, including one from Oneida Lake. We expect the above might be true because nutrients delivered to a lake during colder deeply mixed and possibly ice covered conditions could be less effective at stimulating phytoplankton growth. Results were presented at the GLEON meeting in Australia in December 2018.

Ongoing Project: Evaluating effects of climate change and land use on fisheries production in inland lakes
Yu-Chun Kao, David Bunnell, Mark Rodgers (USGS), Lars Rudstam, Randy Jackson, and 24 collaborators across the globe (Funding from USGS)

We are evaluating effects of climate change and land use on inland fisheries by analyzing time series of fisheries harvests in inland lakes across the globe. Tracking large-scale landscape changes (e.g., land use) as well as annual changes (e.g., water levels that can drive recruitment and fishing access) on a lake-by-lake basis can help inform how long-term trends may influence fisheries. One challenge of analyzing longer time series on a relatively small number of inland lakes is the generality of these results to the millions of inland lakes of the world. Hence, we confront this issue by categorizing lakes based on their depth and vulnerability to food and water security. Previous studies have shown that lake depth is one of the most important factors affecting fisheries production in response to climate change. For example, decreases in lake levels caused by climate change may have strong effects on fisheries production in shallow lakes, potentially via decreased access or littoral area, but not in deep lakes. In addition, regions of the world can be grouped based on their vulnerability to food security and water security, which are important indicators of anthropogenic stressors on lake ecosystems. Thus, land use and climate changes should have disproportionally stronger effects on fisheries production in lakes in regions of higher levels of food and/or water security threat, as these lakes commonly have been stressed by water deficit, pollution, and overfishing.

Completed Project: Macrosystems Biology Research in US lakes across space and time
Pat Soranno (Michigan State), Sarah Collins, Emily Stanley (Univ Wisconsin), Lars Rudstam, Randy Jackson and collaborators across the Northeast and Midwest US (Funding from National Science Foundation to Michigan State)

The CSI Limnology research group has been busy building the LAGOS database, which currently includes both limnological and geospatial information covering ~ 49,000 lakes in a 17-state extent in the Northeastern and Midwestern United States. You can find more information about this group, its recent research efforts, and LAGOS publications on our website (www.csilimnology.org). The database is...
described in LAGOS-NE: A multi-scaled geospatial and temporal database of lake ecological context and water quality for thousands of U.S. lakes and published in GigaScience at the end of 2017. This concludes the direct involvement by CBFS in this project.

**Completed Project: Dreissenid mussel dynamics across systems**
*David Strayer (Cary Institute), Lars Rudstam and 15 collaborators from North America and Europe*

David Strayer led a cross-system analysis of *Dreissena* population dynamics that was completed in 2018. The analysis used all available dreissenid mussel data sets that were more than 10 years long, and Oneida Lake is one of the most detailed of these data sets. The results show no evidence of declining mussel abundance with years since invasions. There were also poor correlation between different age groups of mussels (adults, new recruits, and veligers.). The analysis was submitted, revised and resubmitted to *Ecosphere* in 2018.

**The CBFS Great Lakes Program**

In 2018, CBFS continued to develop our strong Great Lakes research program. CBFS and Buffalo State continued to monitor all five Great Lakes for zooplankton, benthos and chlorophyll, funded by EPA. CBFS also continued a Great Lakes basin research collaboration with the National Ocean and Atmospheric Administration (NOAA) known as the Cooperative Institute for Great Lakes Research (CIGLER). CBFS participated in the Cooperative Science and Monitoring Initiative (CSMI) efforts in Lake Ontario in 2018. A special issue with 18 manuscripts on the GLNPO monitoring program was published in the *Journal of Great Lakes Research* with Burlakova, Karatayev, Hinchey and Rudstam as guest editors. The next special issue with CBFS contributions is on Lake Baikal, based on a meeting on that lake in 2018. CBFS continued leading the Lake Ontario lower trophic level biomonitoring program continuous since 1995 with NYDEC, USGS, and USFWS. We continue to work on two NY Sea Grant projects in Lake Ontario - cisco genetics and tagging Chinook salmon, as well as on two USGS projects on cisco restoration. A new partnership with researchers from Cornell, Buffalo State, Notre Dame, and the U of Guelph is also underway to improve the library of genetic barcodes for Great Lake invertebrates. As part of our reporting, we organized several special sessions at IAGLR 2018, two at the European Large Lakes Symposium -IAGLR meeting in France, and were part of the scientific organizing committee for the ELLS-IAGLR meeting and a meeting on large lakes in Irkutsk, Russia, both in September 2018. Finally, we have three new projects underway, one on the coupling between fish production and lake productivity (Koops et al. GLFC), one on mysid migration (Stockwell et al. GLFC), and one on size spectra analysis (CIGLR).

**Ongoing project: EPA GLNPO Great Lakes monitoring program**
*Lars Rudstam, Jim Watkins, Toby Holda, Annie Scefield, Joe Connolly, Chris Marshall, Gabriella Doud, Beth Whitmore, Pat Boynton, Sarah Schaeffer(Cornell), Alexander Karatayev, Lyubov Burlakova, Knut Mehler, Susan Daniels (SUNY Buffalo State College) (Funded by US EPA Region 5 Great Lakes National Program Office, Chicago, IL)*

In 2018, we continued with the second year of the second 5 year grant on monitoring all five Great Lakes for chlorophyll, zooplankton, mysid shrimp, and benthos (Buffalo State). Benthos sampling now also includes larger surveys in each of the lakes every five years associated with the Cooperative Science and Monitoring Initiative. The US EPA monitors all five Great Lakes each April and August aboard their 180 ft. research vessel, the Lake Guardian. The ship has state of the art sampling equipment including a
Seabird CTD (equipped with sensors for temperature, dissolved oxygen, light, particles and chlorophyll) and onboard laboratory facilities. They also have traditional nets and dredges for plankton and benthic sampling. We explored advanced technology (i.e. hydroacoustics and Triaxus vehicle) in comparison with our traditional measurements. These tools provide high-resolution measurements on horizontal and vertical spatial scales. Zooplankton and mysid samples from these surveys are brought back to CBFS for analysis by our four technicians in our microscopy laboratory. In addition to monitoring, research projects in the grant include mysid biology (Cornell graduate student Toby Holda) and deep chlorophyll layers (Cornell graduate student Annie Scafie). At Buffalo State, our collaborators Karatayev, Burlakova and Mehler use video transect techniques to measure dreissenid mussel abundance. Improved detection of invasive species is an important component of our program. In 2018, another exotic copepod (*Mesocyclops pehpeiensis*) and cladoceran (*Diaphanosoma fluviatile*), new to the Great Lakes were identified by Joseph Connolly and Elizabeth Whitmore in western Lake Erie. Western Lake Erie is the main area with new species in the Great Lakes, which may be associated with warmer temperatures in that basin. Much of the work on the first five year grant was published in 2018 as part of a special issue on the program of the Great Lakes National Program Office in the Journal of Great Lakes Research.

**Ongoing project: NOAA Cooperative Institute for Great Lakes Research (CIGLR)**

*Lars Rudstam as Cornell representative to the Council of Fellows for CIGLR*

In 2017 CBFS and Cornell University entered a five-year research collective led by NOAA’s Great Lakes Environmental Research Laboratory (GLERL) in Ann Arbor, Michigan. Focused on the Great Lakes Basin, this is one of sixteen regional NOAA collaborations nationwide. In addition to Cornell, eight other academic partners from across the basin represent many of the leaders in Great Lake research. This partnership provides CBFS and Cornell unique access to the expertise of agency scientists and the capabilities of government laboratories and vessels, including state-of-the-art equipment. The cooperative also offers funding opportunities to support speakers, post-doctorate researchers, and small research grants. One CIGLR postdoctoral fellow at CBFS and Cornell (Thomas Evans) started working on a project on size spectra analysis in 2018.

**Ongoing Project: Genetic Barcoding of Great Lake invertebrates**

*Lars Rudstam, Jim Watkins, Joe Connolly, Chris Marshall, Beth Whitmore, David Lodge, Lindsay Schaeffer, Nelson Hairston, Jr.(Cornell), Alexander Karatayev, Lyubov Burlakova, Susan Daniels (SUNY Buffalo State College), Michael Pfrender (Notre Dame University), Paul Hebert (University of Guelph) (three individual projects funded by US EPA Region 5 Great Lakes National Program Office, Chicago, IL)*

Genetic barcoding technology has become an important tool in the early detection of invasive species, monitoring diversity, and dietary analysis. However, the current extent of the barcode library for invertebrates in the Great Lakes is very sparse, severely limiting the usefulness of this technology. Effective barcodes depend on accurate identifications, hence the need for a close coordination of taxonomical confirmation and expertise with genetic approaches. The essential goal of this project is to fill in barcodes for all Great Lakes invertebrate species lacking at least 5 established barcodes in the Barcode of Life Directory (BOLD), housed at the University of Guelph. This effort will update what is known about Great Lakes invertebrate biodiversity. Barcodes are short (600 base pairs) genetic sequences, most commonly located as mitochondrial cytochrome oxidase (COI), effective in separate species. This project is divided up into three individual grants focusing on specific taxa, led by Joe Connolly and Sarah Schaefer.
Buffalo State (benthic molluscs and oligochaete worms), Notre Dame (zooplankton and rotifers), and Cornell (benthic arthropods). CBFS will lead taxonomic sorting of copepods, cladocerans, and rotifers within the Notre Dame led project. In 2018, about three hundred individuals of a variety of crustacean species have been identified, documented and sent to BOLD for barcoding. University of Guelph, home of BOLD, is contracted to do the genetic analysis.

**Ongoing Project: Tagging Chinook Salmon in Lake Ontario**

*Jim Watkins, Lars Rudstam (Cornell), Chris Perle (Florida State College), Jesse Lepak (NY Sea Grant), Mike Connerton (NYS DEC) (Funded by New York Sea Grant)*

Following up on initial research in 2017, ten additional Chinook Salmon were tagged with pop-off satellite archival tags (PSATs) in the summer of 2018. Chinook Salmon provide an exciting and economic recreational fishery in Lake Ontario. Chinooks in Lake Ontario are known to heavily depend on alewife forage, but an understanding of specific depth and thermal habitats and predator behavior has been elusive. CBFS scientists collaborated with a charter boat operation in Oswego with their extensive acquired knowledge in collecting fish. Ten mature Chinooks were fitted with pop-off satellite archival tags (PSATs) and released back to the lake to track over several months. These tags collect high resolution data for depth, temperature, light, and acceleration, and upon programmed release, transmit their position and data to satellites. In 2017, tagged fish were tracked to Cobourg Creek on the north shore and the Salmon River, while in 2018 tagged fish travelled to the Niagara and Oswego Rivers as well as the south and north shore. Tag data confirm a general affinity for cool (12-14 C) water temperatures that generally represent the base of the thermocline. Due to the dynamic changes in water column structure, this temperature can represent habitats as deep as 30 m and as shallow as the surface during upwelling. Short term (10 minute) forays into warmer surface waters, presumably to hunt alewife, are timed in late afternoon to sunset. During the day, salmon commonly took short term dives as deep as 100 m. This detailed understanding of Chinook thermal preferences and hunting behavior improves bioenergetics modelling of this important predator, and toward managing this stocked species in a setting with a high interannual variability in the alewife forage base.

**Ongoing Project: Mysis ecology in the Great Lakes**

*Toby Holda, Jim Watkins, Lars Rudstam, Patrick Sullivan (Cornell University), Brian O’Malley, Brian Weidel (USGS), David Jude (University of Michigan), Mary Balcer (University of Wisconsin-Superior), Kelly Bowen (DFO Canada), Jeremy Holden (OMNRF), Mike Connerton (NYSDEC), (funded by GLNPO-EPA, Great Lakes Research Consortium)*

Mysids are an important native species in all the Great Lakes. Understanding mysid ecology is an essential component of understanding these systems as the species is both a major predator on zooplankton and a major prey for alewife, smelt and native coregonids. Even so, there are multiple questions about mysid ecology that remain unanswered. In 2018, we published data on mysis time trends from 2006 to 2016 across the Great Lakes (Jude et al.) and on production of mysids in Lake Ontario (Holda et al.). We continue our studies on mysids at the biomonitoring of these animals concentrating on: 1) spatial patterns and population demographics of Lake Michigan mysids in 2015, 2) temporal trends in mysids abundance in the Great Lakes incorporating additional sampling with zooplankton nets, and 3) models of mysid population dynamics to explore the limits to compensatory responses of the population, and 4) develop SOP for mysid acoustics. In 2018, we also compared capture efficiency of different mysid and zooplankton nets.
On-going project: Lake Ontario and Lake Erie Biomonitoring Program
Kristen Holec, Chris Hotaling, Lars Rudstam (Cornell University), Jana Lantry, Mike Connerton, Chris Legard, and Steve Lapan, Russ McCullough, Dave Lemon, Web Pearsall and Jim Markham (NYSDEC), Brian Lantry and Brian Weidel (USGS); and Zy Biesinger (USFWS). (Funded by NYSDEC)

Ecosystem-based management is an approach to managing environmental issues that considers how an ecosystem functions as a whole rather than focusing on a single species or issue in isolation. In Lake Ontario, managers have used an ecosystem-based approach to managing the productivity and availability of alewife and stocked salmonids since the end of the 1980s. In support of this approach, the New York State DEC initiated research in 1995 called the Lake Ontario Biomonitoring Program (BMP) to evaluate the condition of lower trophic levels in offshore, nearshore, and embayment areas of Lake Ontario. Lower trophic level components (nutrients, phytoplankton, and zooplankton) are indicators of ecosystem health and determine the lake’s ability to support prey fish upon which both wild and stocked salmonids depend. In 2016, this project was expanded to include zooplankton samples from the New York waters of Lake Erie. The BMP is a collaborative project that, in 2019, included the NYDEC Cape Vincent Fisheries Research Station (Lake Ontario), NYDEC Dunkirk Fisheries Research Station (Lake Erie), and regional NYDEC staff at Watertown, Cortland, and Avon; the USFWS Lower Great Lakes Fish & Wildlife Conservation Office; the USGS–Lake Ontario Biological Station; and Cornell University.

Ongoing Project: Biogeochemical and ecological impacts of amphipod circoviruses in benthic habitats.
Kalila Bistolas, Ian Hewson, Jim Watkins, Lars Rudstam (Funded by National Science Foundation)

Benthic amphipods are key indicators of ecosystem health in the Laurentian Great Lakes. Annual monitoring programs depict progressive and precipitous declines in populations of the dominant amphipod, Diporeia spp., in three of the four deep lakes between 1997 and 2018. The mechanism(s) responsible for Diporeia population decline remain unknown. A previous study identified several putative CRESS-DNA viruses associated with Diporeia. The current project corroborates these findings and indicates that CRESS-DNA viruses are common constituents of Diporeia nanobiomes from both Great Lakes and Finger Lakes populations. One previously identified viral genotype, LM29173, is prevalent and recurrent among Lake Michigan and Lake Huron Diporeia. While this viral genotype is more abundant in declining Diporeia populations, we found that the distribution of LM29173 is most closely associated with amphipod haplotype demographics (irrespective of the state of population decline). Since little is known about the role of CRESS-DNA viruses in mediating the ecology, physiology, or mortality of crustaceans, we surveyed the viruses more broadly across crustacean taxa in 2018. This has revealed many new viral types are present in crustaceans.

Ongoing Project: Development of descriptive indices for the spawning and nursery habitat for Great Lakes cisco and their application to areas targeted for restoration.
Matt Paufve, Suresh Sethi, Lars Rudstam (Cornell), Brian Lantry, Brian Weidel (USGS), (Funded by USGS)

Cisco (Coregonus artedi) are a native fish species of conservation concern in the Great Lakes, and are the subject of ongoing management in Lake Ontario. Characteristics of suitable spawning habitat for cisco are not well described and are needed for prioritizing areas targeted for restoration activities. To inform restoration efforts
in Lake Ontario and our general understanding of cisco spawning ecology we are studying spawning sites of established populations in Lakes Superior, Michigan, and Ontario. Our objectives are to (1) define quality habitat for cisco spawning and (2) make inferences about cisco spawning habitat selection and spawning strategies in the Great Lakes. In 2018, we continued egg sampling and habitat measurements at all three study sites, added additional surveys in Lake Ontario, submitted a manuscript describing the results from a controlled experiment to examine the sampling efficiency of our sampling pump, and began data collection and analysis to test if Coregonus sp. eggs can be identified by diameter. Analysis of data from field sampling and for egg identification is currently ongoing.

Completion Report: Dynamics of the deep chlorophyll layer
Annie Scofield, Jim Watkins, Kayden Nasworthy, Lars Rudstam (Cornell), Brian Weidel, Maureen Walsh (USGS), Milan Riha (University of South Bohemia, Czech Rep) (funded by GLFC and EPA-GLNPO)

Deep chlorophyll layers (DCLs) are important features during thermal stratification in large oligotrophic lakes. The presence of a DCL has been observed in all five of the North American Great Lakes, but its ecological significance is not well understood. We collaborated with GLNPO researchers to understand the importance of DCLs for lake production, zooplankton, and fish distributions. Three manuscripts were published in the Journal of Great Lakes Research during 2017 (Watkins et al., Scofield et al., Riha et al.), and additional manuscripts on long-term DCL trends and zooplankton diel vertical migration in Lake Michigan are in preparation. Kayden Nasworthy completed additional experiments on Limnocalanus predation on nauplii with and without algae present, and compared stable isotopes across the five Great Lakes to better understand the trophic position and feeding habits of this important calanoid species.

Completion Report: Testing a metabarcoding approach to food web analysis: application to mysid diets in Lake Ontario
Matt Hare, Lars Rudstam, Toby Holda (Funded by the Great Lakes Research Consortium)

Mysids are one of the major zooplankton predators in Lake Ontario and other Laurentian Great Lakes and are consistently identified as a key component in food web models of these lakes. Mysids also feed on phytoplankton and their role as predators depends on the relative importance of phytoplankton and zooplankton in their diets. Quantifying diets of these animals and other omnivorous zooplankton is therefore central to our understanding of food web dynamics in the Great Lakes, and by extension, the ability of these lakes to support a sustainable fishery. We used universal eukaryotic primers directed at the V4 region of 18S rRNA to amplify and sequence DNA from dissected gut contents of Mysis diluviana from southeast Lake Ontario in July, August, and November 2016. A PNA oligonucleotide was designed to block amplification of Mysis DNA but proved to be only weakly effective because Mysis sequence was a dominant portion of the data obtained despite using dissected stomach contents for DNA extractions. We are not able to exclude the possibility that Mysids were part of the diet. In addition to analyzing field samples, we tested stomach contents of mysids experimentally fed different proportions of cyclopoids and Daphnia. Rough agreement with low, medium, high expected quantities was found for each experimental taxon, helping to optimize the bioinformatic pipeline applied to field samples. These results provide proof-of-concept that metabarcoding can be used to efficiently characterize the diet of mysids, but underscore the need for better databases to make the best use of the data because only 70% of known Lake Ontario crustacean taxa were represented in DNA sequence databases.

Completion Report: Cisco Restoration in Lake Ontario
Ellen George, Matt Hare, Rudstam, Darran Crabtree (TNC), Brian Lantry (USGS) (Funded by New York Sea Grant with contributions from TNC, USGS and USFWS)
Cisco was once a commercially and ecologically important fish in Lake Ontario, before declining in the late 1800’s and early 1900’s due to overfishing, habitat degradation, and impacts from invasive species. Currently, interest in restoring cisco populations in Lake Ontario is growing, as it forms an important part of the native food web and supports native predators such as Atlantic salmon and lake trout. Unfortunately little is known about the status of cisco in Lake Ontario, as critical information such as the distribution and number of spawning populations, the structure and connectedness between these populations, and their level of genetic diversity is unknown. This study aimed to address several of these major knowledge gaps facing cisco restoration in Lake Ontario. First, we evaluated the extent of cisco spawning in the eastern basin by sampling historical spawning sites and areas of suitable habitat with egg collection mats. We were able to confirm cisco spawning in two previously unknown locations; in Henderson Harbor and near Fox and Grenadier Islands. Second, we compared microsatellite diversity of several aggregations of cisco in the eastern basin to assess population structure, genetic diversity, potential legacy effects of a historical genetic bottleneck, and estimate the effective population size ($N_e$) of the Lake Ontario cisco population. Finally, we developed a panel of three nuclear RFLP markers to identify cisco-lake whitefish hybrids. The presence of remnant and/or expanded spawning populations beyond the areas previously known is encouraging for the capacity of cisco populations to recover in Lake Ontario. Lake Ontario cisco have not experienced a detectable genetic bottleneck despite their numerical decline. Cisco genetic diversity is comparable to that found in lake whitefish, and a large effective population size suggests that genetic drift is not currently a risk factor. We found a low rate of hybridization in a sample of coregonine larvae from Chaumont Bay in 2014. However, the majority of adult fish visually identified as possible hybrids were demonstrated with the RFLP marker panel to be a mixture of F1 and backcrosses, suggesting that hybrids survive to adulthood and may reproduce.

Completion Report: Changes in nutrient status and energy flow through lower trophic levels: implications for Great Lakes fishery management

Tom Stewart, Andy Todd (OMNRF), Brian Weidel, David Bunnell (USGS), Lars Rudstam (Cornell), Julie Hinderer (GLFC) (Funded by Great Lakes Fisheries Commission)

The Great Lakes Fishery Commission (GLFC) Science Transfer Board commissioned a workshop process to better understand and communicate relationships among lower trophic level change and fish community and fisheries change in the Great Lakes. Through synthesis of published and unpublished data, literature review, analysis and facilitated discussion among Great Lakes technical experts, a novel conceptual model was developed. Syntheses of the literature and direct observations from Great Lakes technical experts, a novel conceptual model was developed. Syntheses of the literature and direct observations from Great Lakes studies confirmed a strong positive relationship between the total fish biomass and total phosphorus concentration. Variability around this relationship is high and several additional factors can modify the total amount of fish biomass that can be sustained for a given concentration of phosphorus. Modifiers interact and are expressed at the species, community, and food web level of organization. Modifiers include traditional fisheries management activity such as stocking, managing predator-prey balance, fishery regulation, and habitat protection and rehabilitation. Changes in water clarity influence fish communities, fisheries and fish assessments, by changing the catchability of fish, their vulnerability to predation, habitat, distribution and feeding behavior. In shallower waters, increased light penetration induced by reduction in nutrients and dreissenid filtering caused a shift from turbid-phytoplankton dominated system to a clear-macrophyte dominated system with associated shifts in fish community structure. Additionally, food web structure modifies how efficiently, and among what fish species, energy and material is transferred from lower trophic levels. An index of overall transfer efficiency for the Great Lakes overtime, ranged from 3.4 -12.7% with an average of 8.9%. Primary production required...
(PPR) is a food web metric that estimates the accumulated species-group life-cycle acquisition of primary and detrital production. For fully described Great Lakes food webs, PPR is a strong predictor of species-specific biomass. The conceptual model represents testable hypotheses supported by observations informed by expert opinion. Literature, data trends, expert discussions, and preliminary model concepts are detailed in an appended workshop proceedings. A mock-up fact sheet for Lake Huron was developed using the conceptual model as a guide.

**Completion Report: What is the impact on fish recruitment of anthropogenic physical and structural habitat change in shallow nearshore areas in temperate systems? A systematic review protocol**

Pär Byström (Umeå University), Biljana Macura (Mistra, Sweden), Laura Airoldi (University of Bologna, Italy), Brita Klemens Eriksson (Groningen University, Netherlands), Lars Rudstam (Cornell), Josianne Støttrup (Technology University, Denmark). (Funded by Mistra, Sweden)

Background: Shallow nearshore marine ecosystems are changing at an increasing rate due to a range of human activities such as urbanization and commercial development. The growing numbers of construction and other physical and structural alterations of the shoreline often take place in nursery and spawning habitats of many fish and other aquatic species. Several coastal fish populations have seen marked declines in abundance and diversity during the past two decades. A systematic review on the topic was conducted but studies with sufficient rigor to use in a typical meta-analysis was surprisingly rare. Relevant studies include small- and large-scale field studies in marine and brackish systems or large lakes in temperate regions of the Northern and Southern hemispheres, and the 30+ studies of sufficient quality was reviewed and presented in the final report that was completed and submitted in 2018. Because studies were few given the variability in both the anthropogenic structures and the fish communities studied, it was not possible to give a general answer to the question asked. Increasing structure tended to increase fish abundance as long as the anthropogenic structure did not replace natural complex habitat, in which case there was no change. Some species of fish relying on sea grass beds were negatively affected.

**New Project: Lake Ontario 2018 Cooperative Science and Monitoring Initiative (CSMI)**

Jim Watkins, Toby Holda, Joe Connolly, Chris Marshall, Gabriella Doud, Beth Whitmore, Sarah Schaefer, Pat Boynton, Allison Croak, Tram La, Audrey Stanton, Colton Poore (Funding from Great Lakes Restoration Initiative – EPA&USGS)

The Cooperative Science and Monitoring Initiative (CSMI) is a five-year rotation of intensive sampling efforts for each of the five Great Lakes specified within the binational Great Lakes Water Quality Agreement. This increased focus enables higher spatial and temporal resolution of sampling than typical annual surveys. 2018 was the year for intensive sampling of Lake Ontario. CBFS was funded by USGS to collect and process lower food web (phytoplankton, zooplankton, and fish larvae) samples from five cross lake transects. We collaborated with Department of Fisheries and Oceans Canada and US EPA MED in Duluth, MN. CBFS faculty, graduate, and undergraduate students participated in three surveys of Lake Ontario on the R/V Lake Guardian in 2018, including water collection, zooplankton and mysid tows and Triaxus and acoustic transects.

**New Project: Cisco assessment in Lake Ontario**

Suresh Sethi, Lars Rudstam, Taylor Brown (new MSc/PhD student), Brian Weidel (USGS). (Funded by USGS)

Species restorations depend on assessments that can determine if population change results from management actions or natural variability. Great Lakes coregonid restoration actions are advancing rapidly, but are current assessments adequate to determine what is driving coregonid populations? Designing
unbiased surveys requires understanding a species’ seasonal and spatial dynamics and their availability to sampling gear. We argue our current understanding of Great Lakes coregonid life history and habitat use is hampered by contemporary surveys that are seasonally-discrete, inappropriate for target species (ex. bottom trawls rarely catch Cisco), or miss critical habitats (embayments). Lake Ontario provides a unique setting to evaluate coregonid habitat use dynamics across time and space. As the smallest great lake, whole-lake sampling is most practical. It includes the range of diverse deep and shallow-water habitats used by the Great Lakes coregonids. Quantifying pelagic prey fish habitat dynamics across time and space will provide complimentary, collaborative data for parallel projects on Lake Ontario: coregonid larval spatial dynamics, nutrient dynamic modeling (fish as recyclers) and explaining piscivore behavior.

**New Project: Spatial variability and drivers of Mysis partial diel vertical migration.**
*Jason Stockwell (U. Vermont), Brian O’Malley and Brian Weidel (USGS), Lars Rudstam (Cornell)*
*Funded by Great Lakes Fisheries Commission*

Diel vertical migration (DVM) is an important component of food web interactions and population assessments in the Great Lakes. In the case of *Mysis*, a key prey species for Great Lakes fishes, the population is assumed to undergo DVM and migrate into the pelagia at night. Consequently, *Mysis* assessment protocols rely on nocturnal pelagic sampling. *Mysis*, however, exhibit partial DVM (PDVM) – *Mysis* have been observed on the bottom at night in lakes Ontario, Superior, and elsewhere. The proportion of *Mysis* populations which exhibits PDVM is unknown, as are the factors which cause some individuals to remain benthic at night. Recent data from Lake Champlain challenge conventional assumptions about *Mysis* DVM – a substantial portion of the population does not migrate and is thus unavailable to pelagic gear. Furthermore, differences in body size and condition were evident between migrant and non-migrant *Mysis* (e.g., larger individuals were benthic at night). If similar patterns exist in the Great Lakes, where food web models indicate *Mysis* is a key player, then previous biomass estimates based on pelagic sampling underestimate lake wide abundance. We propose to assess variability in benthic-pelagic distributions of *Mysis* in Lake Ontario to test if PDVM is a ubiquitous behavior of *Mysis* in this system, what PDVM may mean for population assessments and food web modeling, and what mechanisms may be driving PDVM. If the night benthic component of *Mysis* populations is high, then a re-evaluation of profundal food web structure/function and outcomes of management actions would be necessary to include more realistic estimates of *Mysis* biomass and distribution. Moreover, if PDVM is related to seasonal patterns in reproductive status, energy reserves, body sizes or environmental conditions, then sampling protocols can be modified to account for these drivers of *Mysis* behavior when determining lake-wide biomass estimates.

**New Project: Using size spectra to assess production potential for fisheries in the Great Lakes.**
*Thomas Evans (new postdoc), Lars Rudstam, Jim Watkins, Doran Mason (NOAA), Zacharias Feiner (Wisconsin DNR)* *(Funded by CIGLR – Cooperative Institute for Great Lakes Research)*

Changes in the structure of community size spectra have been suggested to operate as indicators for ecosystem change or function, but the necessary understanding of how the size structure of communities respond to major ecological change to create useful predictions based on size spectra shifts is lacking. This research will provide a mechanistic understanding of the effects of anthropogenic disturbance on size spectra across a range of ecosystems. The opportunity to use the Great Lakes as a natural experiment allow me to identify spatial heterogeneity in community size structure and its relationship to the taxonomic composition and diversity in aquatic systems. In addition, freshwater size spectra are relatively understudied compared to their marine counterparts. Identifying how size structure responds to ecosystem remodeling, and evaluating the stability of size spectra following ecosystem change, could improve the understanding of processes like niche construction, species coexistence, and the effects of altered energy flows in food webs.
Marten Koops (DFO), Monir Hossain (OMNRF), Ed Rutherford and Hongyang Zhang (NOAA), Lars Rudstam, Randy Jackson (Cornell) (Funded by the Great Lakes Fisheries Commission)

The Great Lakes Water Quality Agreement (GLWQA) has been successful in reducing total phosphorus (TP) loadings, thereby initiating an oligotrophication process across the Great Lakes. Emerging evidence suggests that the Great Lakes are experiencing both an ‘offshore desertification’, whereby low ambient TP concentrations undermine pelagic ecosystem integrity, and in some nearshore areas, blooms of toxic blue-green algae resulting from excess TP. TP is a determinant of ecosystem productivity related to observed biomass at all trophic levels, and has been recognized as a predictor of fish biomass and production for many decades. However, TP reductions have not occurred in isolation; a number of anthropogenic stressors may have affected the energy dynamics that determine how TP is converted into fish biomass. One important stressor is the invasion of dreissenid mussels that have engineered changes in nutrient cycling and lake productivity, and have affected many components of the food web including the production of fish. We propose to examine the phosphorus to fishes (P2F) relationship across multiple systems in the Great Lakes basin to test the hypothesis that recent anthropogenic stressors have changed Great Lakes energy dynamics reducing the efficiency of nutrient conversion to fish biomass. Across systems, TP has also been related to species diversity, and different types of fish communities may respond differentially to TP. Further, the altered biotic interactions associated with dreissenid-invaded food webs will elicit distinct shifts in energy dynamics which may differentially decouple the P2F relationship between pre and post-invasion periods. We will also test the hypothesis that the synergistic effect of TP reduction and dreissenid invasion will vary across habitat types (a spatial effect) and biotic communities (an interaction effect).

CBFS Outreach, Extension and Education Programs

On-going project: Lake Ontario and Oneida Lake Education Initiative
Getchonis, White, Rudstam (funded by the Shackelton Endowment, New York Sea Grant)

The 2018 Education Initiative had a primary focus on the Lake Ontario-Oneida Lake watershed connection and the impacts of algal blooms on the Oneida Lake community. 2018 saw the redesign of the Oneida Lake Travelling Educator Trunk (“Big Red Box”) to now include species and curriculum ideas that are relevant to both Oneida Lake and Lake Ontario. Intern Audrey Stanton worked with Getchonis and White to “rethink” and reorganize these educational materials to include species and issues common to both lakes. The trunks will be distributed to local school districts at an open house for educators in early 2019.

A part of the Education Initiative is the outreach component. Summer 2018 saw a project that looked at the impact of algal blooms on shoreline businesses, lakefront homeowners and recreational lake visitors on Oneida Lake. Intern Colton Poore looked at what has been reported in various media outlets regarding algal blooms and then interviewed businesses, homeowners, and visitors to the lake to explore their knowledge of and impacts that Oneida Lake algal blooms had. Results from the survey still have to be formalized but many of the respondents felt that current algal blooms are no worse now than in years past. Respondents also indicated that news reports and social media exacerbated concerns about algal blooms. Potential future project could compare news reports with actual lake bloom data.
Once again, CBFS Interns worked with Getchonis and New York Sea Grant’s Dave White to promote clean and safe boating at a community event. Children of all ages could try different approved life jackets and were also introduced to the best means of preventing the spread of invasive species between waterways.

**On-going project: Doris Duke Conservation Scholars Program.**
*Angela Fuller, Lars Rudstam, Kristen Holeck, Patrick Sullivan, Martin Feehan (Cornell), Rena Borkhataria (University of Florida). (Funded by the Doris Duke Foundation)*

This grant from the Doris Duke Foundation provided stipends for 4 Cornell students interested in conservation and diversity. The students are provided summer stipends for two summers, the first with a research program (in 2018 all four students were at Shackelon Point, see intern list), and the second summer with a conservation organization. During the year, the scholars meet each second week with a graduate student mentor (with Martine Feehan). They also take a one credit class with leadership training and diversity issues in the conservation field.

**FACILITIES AND MAINTENANCE**

A significant upgrade to the harbor at Shackelton Point occurred in 2018. The old wooden docks were replaced with low maintenance aluminum ones. The slip resistant decking increases safety for those accessing boats. Each section can be rolled in and out of place and attach easily to each other. The poles have a mud pad attached to the bottom of each. The pads sink into the harbor substrate allowing for stability without having to pound the poles in by hand. Seasonal installation and removal is now quicker, easier, and safer for the staff.

Replacement of aging roofs was an important priority in 2018. The Cafeteria, Tower Apartment, and Library all had roof replacements and new gutters installed. The asphalt shingled section of the Greenhouse roof was also replaced. In addition to new roofs, improvements in venting and the addition of water and ice barrier will help prevent ice damage experienced in the past.

A new Ford Escape was purchased as a continuation of the effort to replace aging vehicles at CBFS. It’s equipped with all-wheel drive and provides a nice travel option for our Central New York winter weather.

**GRANTS AND FUNDING**

Funding for the various elements of the research program include the CBFS (Shackelton) Brown endowment and a wide range of public and private agencies.

*Completed in 2018:*
Great Lakes Long-term Biological Monitoring Program. US EPA – Great Lakes National Program Office. (PI Rudstam, co-PIs Watkins, Karatayev (Buffalo State), Burlakova (Buffalo State); $3,850,000, 2012-2018)

FSML: New technology for measuring lower trophic levels in lakes. National Science...
Testing a meta-barcoding approach to food web analysis: application to mysid diets in Lake Ontario. Great Lakes Research Consortium. (PI Hare, co-PI Rudstam; $10,000, 2016-2018)

Vertical habitat of salmonids in Lake Ontario using archival tags and hydrodynamic models. New York Sea Grant (PI Watkins, co-PIs Rudstam, Perle; $183,000, 2016-2019)

Identifying genetic and habitat limitations to cisco restoration in Lake Ontario. New York Sea Grant (PI Hare, co-PI Rudstam; $209,000, 2016-2019)

Understanding declining offshore productivity in the Great Lakes. Great Lakes Fisheries Commission. (PI Stewart, co-PI Rudstam, $30,000, 2017-18)

**Continuing in 2018:**

Ecology and management of warm water fish communities. NY DEC (PI Jackson, co-PI Rudstam; $1,800,000, 2015-2020)


Analysis of lower trophic levels in Onondaga Lake. Onondaga County (PI Rudstam; $50,000, 2015-2019)

Biogeochemical and ecological impacts of amphipod circoviruses in benthic habitats. National Science Foundation. (PI Hewson, co-PI Rudstam; $620,000, 2014-2019)

Development of descriptive indices for the spawning and nursery habitat for Great Lakes Lake Herring and their application to areas targeted for restoration. GLRI (PI Lantry, co-PIs Sethi and Rudstam; $180,000, 2016-2019)

Biomonitoring of Lake Ontario and Lake Erie. NY DEC (PI Rudstam; $120,000, 2017-2019)

Coupled Natural and Human Systems, CNH-L: Linking land-use decision making, water quality, and lake associations to understand human-natural feedbacks in lake catchments. National Science Foundation- administered by Virginia Tech (PI Cobourn, co-PIs Carey, Boyle, Duffy, Hanson; associated: Kemanian, Klug, Soranno, Sorice, Rudstam, Vanni, Weathers; $1,800,000, 2016-2019)

Great Lakes Long-term Biological Monitoring Program. US EPA – Great Lakes National Program Office (PI Rudstam, co-PIs Watkins, Karatayev, Burlakova); $6,000,000, 2017-2022)

DNA Barcoding in the Great Lakes – Invertebrates. EPA Great Lakes National Program Office. (PI Lodge, co-PI Rudstam and others, $400,000, 2017-19)


Cooperative Institute of Great Lakes. (PI Cardinale, University of Michigan, co-PI Rudstam. Agreement of cooperation, 2017-22)

**New initiatives in 2018**

Cisco assessment in Lake Ontario. USGS (PI Sethi, co-PIs Weidel, Rudstam, $100,000, 2018-2020)

Spatial variability and drivers of Mysis partial diel vertical migration. GLFC (PI Stockwell, co-PIs O’Malley, Weidel, Rudstam $120,000, 2018-2021)

Using size spectra to assess production potential for fisheries in the Great Lakes. CIGLR. (PI Rudstam, co-PI Mason, Watkins, Feiner, $70,000, 208-19)

Implications of phosphorus reduction for sustainable Great Lakes fisheries, GLFC. (PI
Koops, coPIs Hossain, Rutherford, Zhang, Rudstam, Jackson, $200,000, 2018-2021)

Status of lower foodweb in Lake Ontario in 2018. CESU. (PI Watkins, co-PI Rudstam; $120,000, 2018-2019)

**PUBLICATIONS AND PRESENTATIONS**

**PhD Thesis:**

**BSc Honors Theses:**
Sophie Hearn. 2018. ESS. Investigating blue-green algae in Oneida Lake; methodological strengths and weaknesses
Shujuan Chen 2018. ESS. Internal and external phosphorus loading in Oneida Lake: Implications for Oneida Lake algae blooms.
Kayden Naysworthy. 2018. ESS. Feeding ecology of calanoid copepod *Limnocalanus macrurus* in the Great Lakes
Jaqueline Doerr. 2018. ESS. The potential for nutrient loading through groundwater seepage in Oneida Lake, New York
Iman Pakzad. 2018. ESS. The effect of round goby invasion on piscivory and growth rates of young-of-year largemouth and smallmouth bass in Oneida Lake
Audrey Stanton. 2018. ESS. Long-term Data Set on Biological Field Station Undergraduate Interns

**Accepted and on-line “pre-prints” of journal articles and book chapters:**
George, EM Social media at #Coregonid2017: extending the reach of a small conference with Twitter and Periscope. Archiv fur Hydrobiologie. Accepted
George, EM, DL Crabtree, MP Hare, and LG Rudstam Early life history of cisco and lake whitefish in Chaumont Bay, Lake Ontario: Distribution and lack of predation by alewife and rainbow smelt. Archiv fur Hydrobiologie. Accepted.
Journal articles:


Chapters in NYSDEC’s Fish Sampling Manual:

Special Issues/Sections of Journals:

Research and technical reports:
Hotaling, CW, LG Rudstam. 2018. Assessing community structure of lower trophic levels in


Presentations and abstracts:

Outreach presentations:


Invited presentations:


Hairston, Jr, NG, LR Schaffner, BE Miner, E Fairchild, P Spaak, L Goveart, SP Ellner. 2018. Eco-Evolutionary Dynamics meets Hydrodynamics: Linking internal waves and
internal P-loading to rapid Daphnia evolution via cyanobacterial blooms. Limnological Institute, University of Konstanz, Germany, December 2018.


Scofield, AE. Long-term change in the Great Lakes lower food web: Importance of deep chlorophyll maxima. SUNY Buffalo Biology Seminar, September 2018

Meeting presentations:
New York Cooperative Fish and Wildlife Research Unit Annual Coordinating Committee Meeting. Albany, NY. Dec. 20, 2018:


GLEON meeting, December 2018, Western Australia


International Conference on Ecological Sciences, Rennes, France Oct. 2018:

Rudstam, LG, JM Watkins, AE Scofield, T Holda. Technological advances improve our understanding of the ecology of zooplankton and fish in large lakes.
Rudstam, LG, F Cannaeto. Lakes and watersheds as a system. Session.

Watkins, JM, LG Rudstam, D Lodge, R Stedman. Cornell University as CIGLR partner.

International Society of Limnology 33 Congress, Nanjing, China, Aug 2018
Zhang, X, Y Tang, Z Liu, E Jeppesen, WD Taylor, L Rudstam, X Mei, V Razlutskij Can filtering mussels improve water quality substantially in shallow lakes?
Rudstam and others: Lake and River Restoration Salon. Question and answer section for Chinese water managers

15th Annual Conference on Rotifers, El Paso, Texas, June 2-9, 2018

Tia Offner, Tony VanDeValk and Tom Brooking

International Association for Great Lakes Research Annual meeting, June 2018
Rudstam, LG, T Holda, A Scofield, J Watkins. Why are there so few mysids in Lake Huron?
George, EM, M Hare, LG Rudstam. Development of species diagnostic RFLP markers for cisco and lake whitefish
Paufve, M, S Sethi, J Jonas, D Yule, E Berglund, M Connerton, D Gorsky, B Weidel, S Furgal, C Karboski, LG Rudstam, J Smith, K Donner, M Chalupnicki, J Palumbo, A Chiodo, M Herbert, C Castiglione, Z Biesinger. Characterizing the spawning and incubation habitat of cisco (Coregonus artedi) in the Great Lakes

Characterizing the spawning and incubation habitat of cisco (Coregonus artedi) in the Great Lakes

Doud, G, JM Watkins, B Weidel, LG Rudstam. Invertebrate predator effects on Daphnia and other zooplankton species.

Holda, T, M Hare, LG Rudstam, B Weidel. Metagenomic analysis of Mysis gut contents.

Scofield, A., J Watkins, K Nasworthy, L Rudstam. Do deep chlorophyll layers have bottom-up effects on zooplankton communities?


Northeast Climate Science Center Seminar, Amherst, MA, Apr 11 2018


New York Chapter of the American Fisheries Society Annual Meeting, Cooperstown, New York, Feb 2018

George, E, D Crabtree, M Hare, D Gorsky, LG Rudstam, M Chalupnicki. Discovery of Cisco spawning locations in Eastern Lake Ontario.


Weidel B, J Palumbo, S Furgal, T Evans, KT Holeck, J Holden, M Connerton. Is Bythotrephes abundance driving recent increases in Lake Ontario Alewife weight-at-age?


GSA symposium of the Department of Natural Resources, Jan 2018:

Paufve, M. Welcoming remarks

Paufve, M. Characterizing spawning and incubation habitat of Cisco (Coregonus artedi) in the Great Lakes.

Fitzpatrick, K. Predator-prey population dynamics model for Chinook salmon management.
AWARDS AND SERVICE

Awards:
2018. Robert L. Kendall Award for the Best Paper in the Transactions of American Fisheries Society in 2017:

Chandler-Misener Award for Best Paper in the Journal of Great Lakes Research in 2017:

Selected for Foundations of Fisheries Science. One of 8 papers in section Managing Fish Communities and Ecosystems: edited by Greg Sass and Michael S Allen:


Service:
George, EM: International Association of Great Lakes Research, Outreach Committee
George, EM: Treasurer, Cornell Student Subunit of the American Fisheries Society
Jackson, JR: Associate Editor, Transactions of the American Fisheries Society.
Jackson, JR: Member, Advisory Panel to the Rare and Endangered Fish Unit of NYSDEC
Jackson, JR: Member, NYSDEC Bureau of Fisheries, Black Bass Research Team
Jackson, JR: Member, NYSDEC Bureau of Fisheries Statewide Database Committee
Jackson, JR: Member, NYSDEC Bureau of Fisheries, Sauger Management Team
Mills, EL: Board of Directors, Oneida Lake Association
Mills, EL: Associate Editor, Aquatic Ecosystem Health and Management
Paufve, M: Co-President, DNR Graduate Student Association
Paufve, M: President, Cornell Student Subunit of the American Fisheries Society
Rudstam, LG: Lake Advisor, Onondaga Lake, Onondaga County, NY
Rudstam, LG: Associate Editor, Journal of Great Lakes Research.
Rudstam, LG: Guest Editor JGLR Special Issue for GLNPO
Rudstam, LG: Guest Editor JGLR special issue on Lake Baikal.
Rudstam, LG: Associate Editor, Aquatic Ecosystem Health and Management
Rudstam, LG: Member, Lake Ontario Technical Committee – New York State
Rudstam, LG: Campus representative for Great Lakes Research Consortium
Rudstam, LG: Council of Fellows, Cooperative Institute for Great Lakes Research
Rudstam, LG: Board member International Association for Great Lakes Research
Rudstam, LG: Program Committee. Joint meeting of IAGLR and European Large Lakes Group
Rudstam, LG. Scientific Program Committee, Advances in Aquatic Ecology, Irkutsk, Russia.
Watkins, JM, Associate Editor, Aquatic Ecosystem Health and Management
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<th>Date</th>
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<td>Syracuse University-shoreline core sampling</td>
<td>Shoreline</td>
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<td>Fish Ecology – Cornell, Rudstam</td>
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