CENTRE FOR EARTH OBSERVATION SCIENCE
(TYPE 1 RESEARCH CENTRE)
ANNUAL REPORT 2017-18

Submitted by: Dr. John Iacozza (Executive Director)

Directors: Dr. John Iacozza (Executive Director)
Dr. David Barber (Science Director)
SUMMARY

CEOS (umanitoba.ca/ceos) is a Type 1 research centre within the Clayton H. Riddell Faculty of Environment, Earth, and Resources at the University of Manitoba. It began in 1994 and over the past 24 years, has grown into an international research centre and one of the world’s largest research centres focusing on Arctic marine systems. CEOS currently has a Senior Canada-150 Research Chair (Dr. J. Stroeve), two CRC-Tier I Chairs (Drs. D. Barber and F. Wang), and a CERC Laureate (Dr. S. Rysgaard).

VISION OF THE CENTRE:

To be global leaders in research, education, training and public outreach on the science and technology related to Earth System Science.

The mission of the Centre is threefold:

(i) Facilitate and conduct research on aspects of the Earth system by using multidisciplinary approaches, creating partnerships with other academic institutions, industries, communities and government agencies;

(ii) Create an environment that fosters the professional and personal development of early career scientists and staff by providing high-quality opportunities for research, education, training and outreach; and

(iii) Communicate key research findings to the scientific community, partners and the general public using efficient and effective methods that reach the broadest audience.

The research conducted at the centre is multidisciplinary and collaborative seeking to understand interrelationships between elements of Earth systems, and how these systems will likely respond to climate change. Although researchers have worked in many regions, the Arctic marine system has always been a unifying focus of activity. Areas of research activity evolve within the Centre but are currently focused on themes such as:

- Arctic Anthropology
- Atmospheric Studies/Meteorology
- Biogeochemistry
- Contaminants
- Earth Observation Science
- Ice-Associated Biology
- Inland Lakes and Waters
- Marine Mammals
- Modelling
- Oceanography
- Sea Ice Geophysics
- Traditional and Local Knowledge

In 2012, CEOS, along with the Greenland Institute of Natural Resources (GINR, Nuuk, Greenland) and the Arctic Research Centre (ARC, Aarhus, Denmark) established the Arctic Science Partnership (ASP), integrating academic and research initiatives. Over the past few years, ASP (asp-net.org) has grown to include other institutions including Université Laval, Alfred-Wegner Institut, Lund University, University of Southern Denmark, University of Tromsø and Fisheries and Oceans Canada. This partnership is an extensive international research collaboration, enabling the world’s leading Arctic scientists to collaborate on projects, coordinated field campaigns, and to take advantage of infrastructure such as research vessels and field stations. As a member of ASP, there is also the opportunity to work in partnership on publications, joint observations and data sharing, and to take part in developing new environmental Arctic technologies.
1.0 PERSONNEL:
In 2017/18 there were more than 130 people directly related to CEOS. Membership in the Centre includes academic staff from various faculties at the University of Manitoba, grant funded research professors at UM, researchers from other universities and government departments who are adjunct to departments at UM, research associates (post-Ph.D. and post-MSc), post-doctoral fellows, graduate students (PhD and Masters), technical support staff and administrative staff.

Note: ¹ denotes that more than 60% of the time is spent on centre-research research
² denotes that less than 60% of the time is spent on centre-related research

FACULTY MEMBERS (*indicates their budgets are administered by CEOS staff)
Genevieve Ali, Assistant Professor, Department of Geological Sciences ²
David Barber*, Distinguished Professor, Department of Environment and Geography (Science Director) ¹
Jens Ehn*, Assistant Professor, Department of Environment and Geography ¹
Norman Halden, Professor, Department of Geological Sciences ²
John Hanesiak*, Professor, Department of Environment and Geography ¹
Mark Hanson, Associate Professor, Department of Environment and Geography ²
John Iacozza, Senior Instructor, Department of Environment and Geography (Executive Director) ²
Dustin Isleifson, Assistant Professor, Department of Electrical and Computer Engineering ¹
Zou Zou Kuzyk*, Assistant Professor, Department of Geological Sciences ¹
David Lobb, Professor, Department of Soil Science ²
Brooke Milne, Associate Professor, Department of Anthropology ²
Puyan Mojabi, Associate Professor, Department of Electrical and Computer Engineering ²
Christopher-John Mundy*, Associate Professor, Department of Environment and Geography ¹
Tim Papakyriakou*, Professor, Department of Environment and Geography ¹
Tricia Stadnyk, Associate Professor, Department of Civil Engineering ²
Søren Rysgaard*, Visiting Professor, Department of Environment and Geography ¹
Feiyue Wang*, Professor, Department of Environment and Geography ¹

GRANT FUNDED RESEARCH PROFESSORS (NIL-SALARY APPOINTMENTS)
Igor Dmitrenko, Research Scientist, Department of Environment and Geography ¹
Ryan Galley, Research Scientist, Department of Environment and Geography ¹
Masayo Ogi, Research Scientist, Department of Environment and Geography ¹
Monika Pučko, Research Scientist, Department of Environment and Geography (until Oct. 2017) ¹
Gary Stern, Research Scientist, Department of Environment and Geography ¹

AFFILIATES
Simon Bélanger, Professor, Département de biologie, chimie et géographie, Université Québec Rimouski
Brent Else, Assistant Professor, Department of Geography, University of Calgary
Steve Ferguson, Research Scientist, Fisheries and Oceans Canada
Casey Hubert, Associate Professor, Department of Biological Sciences, University of Calgary
Lisa Loseto, Research Scientist, Fisheries and Oceans Canada
Robie Macdonald, Research Scientist Emeritus, Fisheries and Oceans Canada
Christine Michel, Research Scientist, Fisheries and Oceans Canada
Lisa Miller, Research Scientist, Fisheries and Oceans Canada
Peter Outridge, Research Scientist, Natural Resources Canada
James Reist, Research Scientist, Fisheries and Oceans Canada
Wojciech Walkusz, Research Scientist, Fisheries and Oceans Canada
RESEARCH ASSOCIATES (POST-PH.D.)

- Nicolas-Xavier Geilfus¹
- Joel Heath²
- Sergei Kirillov¹
- Marcos Lemes¹
- Zhou (George) Liu¹
- Jennifer Lukovich¹
- Greg McCullough¹

RESEARCH ASSOCIATES (POST-M.S.C.)

- David Babb¹
- Lucette Barber¹
- Alexis Burt (until Aug. 2017)¹
- Lauren Candlish¹
- Ashley Gaden¹
- Michelle Kamula¹
- David Landry¹
- Thomas Neusitzer¹
- Nathalie Thériault (until Dec. 2017)¹
- Emmelia Wiley¹

POSTDOCTORAL FELLOWS

- David Capelle¹ – Supervisor: Papakyriakou
- Diana Chirkova¹ – Supervisor: Stern
- Odile Crabeck¹ – Supervisor: Rysgaard
- Nari Firoozy¹ – Supervisor: Barber (start Aug. 2017)
- Virginie Galindo¹ – Supervisor: Rysgaard (until Nov. 2017)
- Carie Hoover¹ – Supervisor: Loseto
- Pardis Karimalavijeh¹ – Supervisor: Stern (start Jan. 2018)
- Jack Landy¹ – Supervisor: Barber (until June 20, 2017)
- Kathleen Munson¹ – Supervisor: Wang/Stern
- Sonja Ostertag¹ – Supervisor: Loseto
- Thomas Richerol¹ – Supervisor: Barber/Rysgaard (until Nov. 2017)

PH.D. STUDENTS: In 2017/18, there were 27 PhD students and candidates supervised by faculty members in CEOS. Their names, department and advisors are listed below.

<table>
<thead>
<tr>
<th>Name</th>
<th>Department</th>
<th>Advisor(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samuel Bansah</td>
<td>Geological Sciences</td>
<td>Ali</td>
</tr>
<tr>
<td>Atreya Basu</td>
<td>Environment and Geography</td>
<td>Ehn</td>
</tr>
<tr>
<td>Wieter Boone</td>
<td>Geological Sciences</td>
<td>Rysgaard/Dmitrenko</td>
</tr>
<tr>
<td>Tonya Burgers</td>
<td>Environment and Geography</td>
<td>Papakyriakou</td>
</tr>
<tr>
<td>Luis Gerardo Chaves</td>
<td>Environment and Geography</td>
<td>Hanson</td>
</tr>
<tr>
<td>Cassandra Debets</td>
<td>Biological Sciences</td>
<td>Ferguson</td>
</tr>
</tbody>
</table>
### Masters Students:

In 2017/18, there were 34 Masters students supervised by faculty members in CEOS. Their names, department and advisors are listed below.

<table>
<thead>
<tr>
<th>Name</th>
<th>Department</th>
<th>Advisor(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wilhemina Armah</td>
<td>Geological Sciences</td>
<td>Kuzyk</td>
</tr>
<tr>
<td>DongYong Back</td>
<td>Environment and Geography</td>
<td>Mundy</td>
</tr>
<tr>
<td>Neal Bailey</td>
<td>Environment and Geography</td>
<td>Wang</td>
</tr>
<tr>
<td>Oksana Banias-Schimnowski</td>
<td>Environment and Geography</td>
<td>Barber</td>
</tr>
<tr>
<td>Jennifer Bruneau</td>
<td>Environment and Geography</td>
<td>Hanesiak</td>
</tr>
<tr>
<td>Yanique Campbell</td>
<td>Environment and Geography</td>
<td>Barber/Ehn</td>
</tr>
<tr>
<td>Laura Dalman</td>
<td>Environment and Geography</td>
<td>Mundy/Barber</td>
</tr>
<tr>
<td>Durell Desmond</td>
<td>Environment and Geography</td>
<td>Stern/Barber</td>
</tr>
<tr>
<td>Maha Ghazal</td>
<td>Biological Sciences</td>
<td>Ferguson</td>
</tr>
<tr>
<td>Madison Harasyn</td>
<td>Environment and Geography</td>
<td>Barber/Isleifson</td>
</tr>
<tr>
<td>Claire Herbert</td>
<td>Environment and Geography</td>
<td>Barber</td>
</tr>
<tr>
<td>Elenore Hood</td>
<td>Anthropology</td>
<td>Milne</td>
</tr>
<tr>
<td>Justine Hudson</td>
<td>Biological Sciences</td>
<td>Marcoux</td>
</tr>
<tr>
<td>Samantha Huyghe</td>
<td>Geological Sciences</td>
<td>Kuzyk</td>
</tr>
<tr>
<td>Holly Kajpust</td>
<td>Environment and Geography</td>
<td>Hanson</td>
</tr>
<tr>
<td>Zakhar Kazmiruk</td>
<td>Geological Sciences</td>
<td>Kuzyk</td>
</tr>
<tr>
<td>Skye Kushner</td>
<td>Environment and Geography</td>
<td>Wang</td>
</tr>
<tr>
<td>Jennifer Leslie</td>
<td>Environment and Geography</td>
<td>Hanson</td>
</tr>
<tr>
<td>Jasmine Liesch</td>
<td>Anthropology</td>
<td>Milne</td>
</tr>
<tr>
<td>Chelsea Lobson</td>
<td>Environment and Geography</td>
<td>Hanson</td>
</tr>
<tr>
<td>Kathleen MacMillan</td>
<td>Environment and Geography</td>
<td>Loseto</td>
</tr>
<tr>
<td>Thomas Neustizer</td>
<td>Electrical &amp; Computer Engineering</td>
<td>Barber/Mojabi</td>
</tr>
<tr>
<td>Wesley Ogloff</td>
<td>Biological Sciences</td>
<td>Ferguson</td>
</tr>
</tbody>
</table>
Nicole Pogorzelec  Environment and Geography  Mundy/Gough
Scott Pokorny  Civil Engineering  Ali/Stadnyk
Matthew Randall  Environment and Geography  Hanson
Kevin Scharffenberg  Biological Sciences  Loseto
James Singer  Environment and Geography  Wang
Nolan Snyder  Environment and Geography  Wang
Tassia Stainton  Geological Sciences  Kuzyk
Adam Vanderpoint  Environment and Geography  Hanson
Elizabeth Worden  Environment and Geography  Oakes/Loseto
Greg Zajac  Electrical & Computer Engineering  Isleifson
Kyle Ziolkowski  Environment and Geography  Hanesiak

**Technical Support Staff**

- Debbie Armstrong – UCTEL Technician
- David Binne – SERF Technician
- Karley Campbell – Technician (until Feb 2018)
- Ashley Elliot – Technician (until Aug 2017)
- Thor Halldorson – Technician (until Jan 2018)
- Rachel Hussherr - Technician
- Justine Hudson – Student Technician
- Ainsleigh Loria - Technician
- Sebastian Luque – Technician
- Lucas Morgan Martin-Tully – Technician
- Dale Maxwell - Technician
- Wesley Ogloff – Student Technician
- Jake Richie – Technician
- Ashley Soloway – Technician
- Heather Stark – Churchill Marine Observatory (CMO) Coordinator

**Administrative, Secretarial or Support Staff**

- Michelle Clyde – School on Board Coordinator (until Mar 2018)
- Wayne Chan – Research Computer Analyst
- Linda Chow – Office Assistant
- Claire Herbert – Lake Winnipeg Basin Portal Coordinator
- Jennifer Hollar – Office Assistant
- Aggie Roberecki – Administrative Assistant
- Denise Whynot – Project Contaminants Coordinator
2.0 ACADEMIC CONTRIBUTIONS

LIST OF PUBLICATIONS

(A) Books and Monographs (authored)


(B) Books (editor)

(C.1) Referred Publications
Researchers in CEOS published (or co-published) upwards of 400 peer-reviewed publications since 2012. These are listed below.


Choy, E.S., B. Rosenberg, J.D. Roth and L.L. Loseto. (2017) "Inter-annual variations in environmental factors affect prey and body condition of eastern Beaufort Sea beluga whales (Delphinapterus leucas)". Marine Ecology Progress Series, 579: 201-212.


continued importance of the hunting for Inuit food sources.


Ocean?

Enantiomer Fraction (EF): A Novel Approach to Calculate the Ventilation Age of Water in the Arctic

Pućko, M

and the Envi

biont in terrestrial edge

Prosser, R.,

ice”

Poulin, M.

whale (Balaena mysticetus) populations

and stable isotope cycles in baleen plates are consistent with year

Pomerleau, C.,

mysticetus)

““FTIR imaging analysis of cell content in sea-ice diatom taxa during a spring bloom in the lower

Northwest Passage of the Canadian Arctic”, Marine Ecology Progress Series, 569: 77-88.


assemblage isotopic variability as a tool for assessing diet and the spatial distribution of bowhead

whale Balaena Mysticetus foraging in the Canadian Eastern Arctic.” Marine Ecology Progress Series,


Pomerleau, C., V. Lesage, G. Winkler, B. Rosenberg and S.H. Ferguson. (2014) "Contemporary diet of

bowhead whales (Balaena mysticetus) from the Eastern Canadian Arctic inferred from fatty acid


zooplankton communities and stable isotope ratios (δ13C and δ15N) in relation to oceanographic

conditions in the sub-Arctic Pacific and Western Arctic regions during the summer of 2008". Journal of

Plankton Research, 36(3): 757-775.


and the combined effects of acidification/lipid extraction on carbon stable isotope ratios for sub-arctic


zooplankton communities in the Northeast subarctic Pacific Ocean". Journal of Plankton Research,


concentrations of mercury and stable isotope ratios of carbon (d13C) and nitrogen (d15N) in marine


“Reconstructing variability in West Greenland ocean biogeochemistry and bowhead whale (Balaena


and stable isotope cycles in baleen plates are consistent with year-round feeding in two bowhead

whale (Balaena mysticetus) populations”. Polar Biology, 1-13.


ice". Diatom Research, 29(2): 213-221. doi:10.1080/0269249X.2013.877085

Prosser, R., J. Anderson, M. Hanson, K. Solomon and P. Sibley. (2016). "Indirect effects of herbicides on

biota in terrestrial edge-of-field habitats: A critical review of the literature". Agriculture, Ecosystems,


Enantiomer Fraction (EF): A Novel Approach to Calculate the Ventilation Age of Water in the Arctic


(Boreogadus saida) from the Beaufort Sea and associative fish health effects”. Environmental science & technology, 48(19): 11629-11636.


(C.2) Papers in Periodicals

Iacozza, J. 2015. **Greenland Sea Ice Course**. Clayton H. Riddell Faculty of Environment, Earth, and Resources Newsletter. Summer 2015

Iacozza, J. 2015. **Learning about the Arctic…IN THE ARCTIC**. Clayton H. Riddell Faculty of Environment, Earth, and Resources Newsletter. Spring 2015

(E.1) Contributions to Government Documents


(E.2) Bulletins and Conference Proceedings


Babb, D.G., R.J. Galley, J. Landy and D.G. Barber, “Multiyear sea ice loss in the Beaufort Sea: melt, transport and the transition towards a seasonal ice cover”, presented at Arctic Change 2017, December 2017, Quebec, Canada.


Babb, D.G., J. Landy, J. Andrews, L. Candlish, N. Theriault, J. Ehn and D.G. Barber, Sea ice in Hudson Bay: a summary of recent findings and ongoing research, International Arctic Change Conference, Québec City, 11-15 December 2017


Babb, D.G., J.V. Lukovich, D.G. Barber, “Sea ice motion within the Beaufort Gyre”, Presented at International Polar Year – From Knowledge to Action, April 2011, Montreal, QC, Canada.


Campbell, Y., J. Ehn, D. Barber, Effect of a storm during the sea ice minimum extent, International Arctic Change Conference, Québec City, 11-15 December 2017

Carrie, J., G.A. Stern. (2014). Ecosystem drivers of mercury bioaccumulation and biomagnification in pan-Arctic marine zooplankton. ASM program. ArcticNet Science Meeting (ASM), Ottawa, Canada


Ehn, J. K., Light interactions in the ice-ocean system, First Arctic Science Partnership (ASP) Annual Meeting, Gimli, Manitoba, Canada, 12-16 November 2012


Galindo, V., Gosselin, M., Mundy, C.J., Lavaud, J., Ehn, J., Rysgaard, S., Pigment composition and photoprotection of Arctic sea ice algae during spring, 24th International Diatom Symposium, Quebec, 21-26 August 2016

Galindo, V., Gosselin, M., Mundy, C.J., Claustre, H., Ehn, J., Rysgaard, S., Pigment composition and photoprotection of Arctic sea ice algae, ArcticNet Annual Scientific Meeting, Winnipeg, 5-9 December 2016


Guzzi, A., M. Warbanski, J. Heath, M. Kamula, J. Ehn, and Z.Z. Kuzyk, Freshwater and nutrient distribution in coastal waters of James Bay and Southeast Hudson Bay, Hudson Bay Summit, Montréal, 27 February -1 March 2018


Hubert, C., G.A. Stern. (2016). GENICE: Microbialgenomics for oil spill preparedness in Canada’s Arctic marine environment. ASM program. ArcticNet Science Meeting (ASM), Winnipeg, Canada


Kamula, Michelle, C. Grant, B. Misiuk, M. Mahy, C. Vis, K. Regular, Z. Kuzyk, G. Stern, P. Archambault, E. Edinger. (2017). Wager Bay (Ukkusiksaliq National Park) and Chesterfield Inlet marinebaseline study. Conference program. International Arctic Change meeting, Quebec City, Canada


Lambert-Girard, S., E. Leymarie, S. Marty, L. Matthes, D. Antoine, J. Ehn and M. Babin, Direct measurements of the radiance distribution beneath Arctic landfast sea ice during the spring transition, International Arctic Change Conference, Québec City, 11-15 December 2017


Landy, J., J. Ehn, D. Barber, J. Stroeve, and M. Tsamados, Utilizing IceSat and CryoSat-2 altimeter data to predict the albedo of Arctic sea ice during summer, International Arctic Change Conference, Québec City, 11-15 December 2017

Landy, J., Diaz, A., Scharien, R., Ehn, J., Else, B., and Mundy, C.J., Quantifying dynamic thermodynamic interactions within melting first-year sea ice (UK-Canada Arctic Partnership 2017), International Arctic Change Conference, Québec City, 11-15 December 2017

Loria, A., A. Burt, G. Stern. (2015). Regional comparison of the THg, MeHg and PAH concentrations in decapods in the Beaufort Sea from 2012-2014. ASM program. ArcticNet Science Meeting (ASM), Vancouver, Canada

Loria, A., A. Burt, G. Stern. (2016). Regional comparison of the MeHg and PAH concentrations in decapods in the Beaufort Sea from 2012-2014. ASM program. ArcticNet Science Meeting (ASM), Winnipeg, Canada


Matthes, L., Mundy, C.J., Lambert Girard, S., Hodgson, R., Verin, G., Babin, M., Ehn, J., Spring progression of spectral light transmission through landfast sea ice during the melt season on the Arctic continental shelf of Baffin Bay. ArcticNet Annual Scientific Meeting, Winnipeg, 5-9 December 2016

Matthes, L., Mundy, C.J., Lambert Girard, S., Pogorzelec, N., Babin, M., and Ehn, J., Characterization of the under-ice light field and availability of photosynthetically active radiation during a sea ice spring melt progression, International Arctic Change Conference, Québec City, 11-15 December 2017

Matthes, L., Mundy, C.J., Lambert Girard, S., Hodgson, R., Verin, G., Babin, M., Ehn, J., Spectral light transmission through landfast sea ice during the melt season in southern Baffin Bay, Biogeochemical Processes at Sea Ice Interfaces (BEPSII) Annual Meeting, La Jolla, USA, 3-5 April 2017


Mundy, C.J., Ehn, J., Leu, E., Gosselin, M., Campbell, K., Arctic spring: key processes influencing timing of primary producers in ice-covered waters, The 45th International Liège Colloquium, Primary production in the ocean: from the synoptic to the global scale, Liège, Belgium, 13-17 May 2013

Mundy, C.J., McDonald, S., Ehn, J.K., Functional data analysis of spectral transmittance during an under-ice Phaeocystis bloom, Boom or Bust Project Annual Workshop, Tromsø, Norway, 19 October 2016

Mundy, C.J., Milne, B., Ehn, J., Barber, D.G., Kuzyk, Z.Z., Papakyriakou, T., Ferguson, S., Hedges, K., Michel, C., Blanchfield, P., Walkusz, W., Brown, T. Southampton Island Marine Ecosystem Project (SIMEP), MEOPAR NCE Annual Scientific Meeting, Montreal, 21-22 June 2017


Munson K., Stern G., Wang F. (2017). Increases in fish mercury from historicallyimpounded and nearby reference water bodies of northern Manitoba. 13th International Conference on Mercury as a Global Contaminant (ICMGP), Providence, United States
Neumeier, U., M. Gosselin, V. Galindo, G. St-Onge, H. Xie, S. Bélanger, Z. Kuzyk, J. Ehn, A. Rochon, J.-C. Montero-Serrano, S. Senneville, and R. Costanzo, Coastal oceanography project for the eastern James Bay (Northern Quebec, Canada), International Arctic Change Conference, Québec City, 11-15 December 2017


Petrusevich, V., I. Dmitrenko, J. Ehn, S. Kirillov, S. Rysgaard, D. Barber, Mechanisms of zooplankton diel vertical migration in Young Sound Fjord during the polar night, ArcticNet Annual Meeting 2014 – Arctic Change


Pogorzelec, N.M., Mundy C.J., Findlay, C.R., Campbell, K., Diaz, A., Ehn, J.K., Rysgaard, S., Gough, K.M., FTIR imaging analysis of cell content in sea-ice diatom taxa during a spring bloom in the lower Northwest Passage of the Canadian Arctic, 24th International Diatom Symposium, Quebec, 21-26 August 2016

Pogorzelec, N.M., Mundy C.J., Findlay, C.R., Campbell, K., Diaz, A., Ehn, J.K., Rysgaard, S., Gough, K.M., FTIR imaging analysis of cell content in sea-ice diatom taxa during a spring bloom in the lower Northwest Passage of the Canadian Arctic, ArcticNet Annual Scientific Meeting, Winnipeg, 5-9 December 2016


Pucko, M., G. Stern, L. Jantunen, T. Bidleman, R. Macdonald, D. Barber, N.-X. Geilfus, S. Rysgaard, A. Burt. (2016). Current use pesticide(CUPS) and legacy organochlorine pesticide (OCP) dynamics at the ocean-sea ice-atmosphere (OSA) interface in Resolute Passage, Canadian Arctic, during the winter-summer transition. ASM program. ArcticNet Science Meeting, Winnipeg, Canada

Quiring, C., Ehn, J., McDonald, S., Pogorzelec, N., Mundy, C.J., Bio-optical characterization of snow-covered sea ice in Baffin Bay, near Qikiqtaaluk, Nunavut, ArcticNet Annual Scientific Meeting, Winnipeg, 5-9 December 2016

Ritchie, J., J. Carrie, K. Foster, A. Burt, G. Stern. (2014). Baseline assessment of hydrocarbons in benthic invertebrates in Baffin Bay prior to oil and gas exploration and extraction and increase shipping traffic. ASM Program. ArcticNet Science Meeting (ASM), Ottawa, Canada


Singer J., Munson K., Wang F. (2017). Mercury methylation in reservoirs of northern Manitoba, Canada: effects of hydroelectric regulation and climate change. 13th International Conference on Mercury as a Global Contaminant (ICMGP), Providence, United States

Stern, G., P. Outridge, A. Gaden. (2014). Integrated Regional Impact Study (IRIS) of the western and central Canadian Arctic. ASM program. ArcticNet Science Meeting (ASM), Ottawa, Canada


Wang F. (2016). Mercury biogeochemical cycling in the cryosphere. 99th Canadian Chemistry Conference and Exhibition,

Wang F. (2017). Cryo-reactions and Arctic marine cryospheric chemistry. 100th Canadian Chemistry Conference and Exhibition, Toronto, Canada


(G) Papers Published by Research Centre


GRADUATES
In the 2017/18 fiscal year, 14 students associated with CEOS graduated from their respective graduate programs. The following are the students, along with their thesis/dissertation title and the name of their supervisor(s).

Thesis Title: “Climate change and sea ice: shipping in Hudson Bay, James Bay, Hudson Strait, and Foxe Basin”.

Karley Campbell (Ph.D.) Environment and Geography, Advisors: C.J. Mundy and S. Rysgaard.
Dissertation Title: “Assessment of the factors controlling sea ice algal and bacterial production in Dease Strait of the Northwest Passage”.

Emily Choy (Ph.D.) Biological Sciences, Advisor: L. Loseto.
Dissertation Title: “The interconnectedness of diet, physiology, and physical condition in beluga whales as a sentinel species for environmental change in the Beaufort Sea ecosystem”.

Odile Crabeck (Ph.D.) Geological Sciences, Advisors: S. Rysgaard and R. Galley
Dissertation Title: “Gas Content and Transport in Cold First Year Sea Ice”.

Aura Diaz (M.Sc.) Environment and Geography, Advisors: J. Ehn and T. Papakyriakou.
Thesis Title: “The Energetics of Extensive Melt Water Flooding of Level First-Year Sea Ice in Cambridge Bay, Nunavut, Canada”.

Rosemary (Annie) Eastwood (M.Sc.) Environment and Geography, Advisor: ZZ. Kuzyk.
Thesis Title: “Physical properties and isotopic characteristics of the winter water column and landfast sea-ice surrounding the Belcher Islands, southeast Hudson Bay”.

Jemma Harrison (M.Sc.) Geological Sciences, Advisor: ZZ. Kuzyk.
Thesis Title: “Shoreline carbonate structures in West Reflex Lake, Alberta-Saskatchewan”.

Scott Kehler (M.Sc.) Environment and Geography, Advisor: J. Hanesiak.
Thesis Title: “Cases of elevated deep moist convection initiation above frontal surfaces in 2015”.

Krista Kenyon (M.Sc.) Environment and Geography, Advisors: D. Barber and S. Ferguson.
Thesis Title: “Movement patterns and winter habitat use of narwhal (Monodon monoceros) in the Eastern Canadian Arctic”.

Heather Kyle (M.Sc.) Geological Sciences, Advisor: S. Rysgaard.
Thesis Title: “Quantification of ikaite in first and multi year sea ice”.

Thomas Neusitzer (M.Sc.) Electrical & Computer Engineering, Advisors: P. Mojabi and D. Barber
Thesis Title: “On the dielectric properties and normalized radar cross-section of crude oil-contaminated sea ice”.

Thesis Title: “Spatiotemporal dynamics of water quality analytes within an intensively managed prairie watershed”.

Christine Quiring (M.Sc.) Environment and Geography, Advisors: C.J. Mundy and J. Ehn.
Thesis Title: “Bio-optical characterization of bottom ice algae in snow-covered landfast sea ice in Baffin Bay, Nunavut”.

Tyler Tiede (M.Sc.) Electrical & Computer Engineering, Advisors: P. Mojabi and D. Barber
Thesis Title: “Inversion of surface contacting antenna measurements for sea ice complex permittivity reconstruction”.


OTHER ACADEMIC ACTIVITIES

Research Projects
CEOS faculty members are principal investigators on a large number of research projects conducted in the Arctic, as well as other parts of the world. These projects which were active in 2017/18 are described below.

BaySys (Hudson Bay System Study): Contributions of Climate Change and Hydroelectric Regulation to Freshwater-Marine Coupling Processes in the Hudson Bay System. BaySys is a multiyear (April 2015-September 2019) research collaboration among NSERC’s Collaborative Research and Development Program (CRD), Manitoba Hydro and the Universities of Manitoba, Northern British Columbia, Quebec a Rimouski, Alberta, Calgary, Laval, and Trent, to conduct research on Hudson Bay. The main objective of the Hudson Bay System Study (BaySys) is to examine the influence of freshwater on Hudson Bay marine and coastal systems. Specifically, to provide a scientific basis to separate climate change effects from those of regulation of freshwater on physical, biological and biogeochemical conditions in Hudson Bay. This objective is being addressed through a “systems” perspective, with sub-objectives to examine the climate, marine, and freshwater systems, and to study the cycling of carbon and contaminants.

Over the past year, the following was accomplished:

Fieldwork: From May to July 2018, the Amundsen BaySys cruise successfully completed the first ever bay-wide survey of the marine ecosystem at the time when the freshet was at maximum and the ice cover still in place. This field campaign was an enormous success with an unprecedented 122 sampling stations completed, making use of the CCGS Amundsen, helicopter, barge, and zodiac. These are categorized as 45 stations on board the vessel, 53 stations via helicopter, and 24 stations via a combination of zodiac and barge operations. This has resulted in thousands of water, sea ice, sediment, and biological samples collected. The sheer volume of samples collected illustrates the success of the field campaign; however it also alters the timeline until completion. Teams are cognizant of the BaySys timeline and have prioritized and expedited samples for analysis and developed revised timelines for HQP theses, other research output (peer-reviewed publications), and the BaySys synthesis report.

Modeling: Our modeling teams were able to accomplish a number of tasks this year, including the preparation of climate scenarios, the setup of a HYPE model for the Hudson Bay Drainage Basin spanning >1/3 of Canada’s landmass, and preparation of standardized meteorological forcing for multi-model uncertainty assessment that will be conducted throughout the modeling process. As of summer 2017, Team 6 was established to coordinate with Team 2 on freshwater and marine modelling efforts. This new team is dedicated to understanding the relative impacts of climate change and regulation from a climate modeling perspective, using the Nucleus for European Modeling of the Ocean (NEMO) general circulation model coupled with LIM2 for sea ice. This team was able to use initial NEMO simulations to assess freshwater dynamics in the Hudson Bay Complex, and these simulations were evaluated using existing and recent winter field campaign observational data from 2016/2017.

Our modeling teams continued to progress with their tasks throughout the winter months. And in December, a proposal was outlined and prepared for the new team to be approved by the Science Steering and Research Advisory Committees in February. Both modeling teams continued discussions on progress, variable inputs and outputs into the runs, and regional model domains throughout the winter. Bias corrections were re-done for the GCM models of both NEMO and HYPE, and runoff scenarios were completed in mid-summer 2018.

Meetings: On December 6, 2017, BaySys held its annual All-Hands Meeting at CEOS. The All-Hands Meeting allowed BaySys team members to provide updates on the current status of their research in light of the data collection delays from earlier in the year, and to discuss their aims to meet the overall
objectives of the project. These meetings provided an opportunity for both university and industry partners to discuss the project as a whole, and to plan for further integration going forward. A second and more extensive two-day workshop is planned for November 15-16, 2018.

The BaySys Climate Change vs. Regulation Assessment Workshop took place at Manitoba Hydro on September 18, 2018. This workshop brought all teams together to discuss analysing and integrating the observational data with the NEMO and HYPE modelling outputs. The focus of the workshop was placed on finding consistent approaches for teams to use the data and models effectively and that will ultimately provide insight towards the overall BaySys objectives. All six teams presented on their datasets, the required modeling data, and their plans to quantify relative climate change and regulation impacts. The result of this workshop was a smaller sub-group that will: i) identify standardized diagnostics for all teams; ii) develop a baseline evaluation with 2016-2018 data; iii) coordinate uncertainty analyses between teams; and iv) identify the appropriate forums for the analyses (technical reports, synopsis, peer-reviewed publications, etc).

Beginning in January 2018, the BaySys coordination team began the preparation for a Knowledge Exchange Workshop, planned for the end of the CCGS Amundsen cruise on July 3-4, 2018 in Churchill MB. This event, hosted in partnership with Minister Carr, brought Members of Parliament, Senators, Chiefs, community members and industry leaders on to the CCGS Amundsen to discuss the impact of climate change on communities, industry, tourism, and the ongoing research being conducted in Hudson Bay through the BaySys project. Along with the successful Knowledge Exchange Workshop, two separate community visits were planned prior to the 2018 CCGS Amundsen Cruise, one for the Chesterfield Inlet community and one for the Churchill community.

Churchill Marine Observatory: The University of Manitoba’s Canada Foundation for Innovation (CFI)-funded Churchill Marine Observatory (CMO) is a globally unique, highly innovative, multidisciplinary research facility to be located in Churchill, Manitoba, adjacent to Canada’s only Arctic deep-water port. The CMO directly addresses technological, scientific, and economic issues pertaining to Arctic marine transportation and oil and gas exploration and development throughout the Arctic. The facility consists of three components: the Oil in Sea Ice Mesocosm, the Environmental Observatory, and a coastal research vessel, the Marine Vessel (MV) William Kennedy (Figure 2.1). The construction of the main facility of the CMO commenced in spring 2017 however was put on hold when the railway flooded out in May 2017. Construction of the facility commenced again in August 2018 with the shipment of foundation materials brought in via SeaLift. With the return of rail service to Churchill in autumn 2018, the CMO facility has an anticipated opening date of winter 2020.

The Environmental Observing (EO) system is a key part of the CMO’s facility as it provides a state-of-the-art monitoring system for Hudson Bay. The EO system is located along the main shipping channel across Hudson Bay and Strait and is supported by a coastal research vessel. The EO system contains a network of 4 oceanographic moorings which will be used to scale process studies conducted at the CMO’s Oil in Sea Ice Mesocosm (OSIM) facility. In addition, they provide advanced capability to monitor for and quantify potential impacts from shipping and development activities in the Arctic. The oceanographic moorings contain a large suite of monitoring instruments, including CTD’s, fluorescence sensors, ice motion sensors, sediment traps, ocean current sensors, and passive acoustic monitors for marine mammal detection. A subset of these instruments, particularly the CTDs, fluorescence sensors, and passive acoustic monitors, were purchased through the support provided by Polar Knowledge Canada. The instruments were integrated into the moorings designed by ASL Environmental Science and installed in Hudson Bay in June 2018 via the CCGS Amundsen. The vessel is used to assist in scaling studies from the Churchill River estuary through the ice-free season of Hudson Bay.
The University of Manitoba and the Arctic Research Foundation established an agreement under the auspices of the CMO to retrofit a 65-foot fishing trawler for Arctic science operations within Hudson Bay. The retrofit and scientific mobilization of the *MV William Kennedy* took place from April 2017 to June 2018 in Summerside, Prince Edward Island. The retrofit included the addition of berth spaces for crew and science personnel, a large lab space with acid resistant bench tops and a fume hood, along with the purchase of operational deck equipment (ex., electric winches, crane, A-frame, etc.). The integration of a SeaBird Electronics Rosette water collection system, a ship-based flow-through water system, and other smaller science equipment completed the scientific mobilization of the *MV William Kennedy*. The MV *William Kennedy* departed port in July 2018 for its first scientific expedition in Hudson Bay. In August 2018, the vessel went on its inaugural scientific cruise in Hudson Bay. Two programs lead by CEOS faculty used the vessel in the summer of 2018: the Southampton Island Marine Environmental Project (SIMEP) run by Dr. CJ Mundy, and the GENICE Project, run jointly by Dr. Gary Stern and Dr. Casey Hubert (University of Calgary).

**Southampton Island Marine Ecosystem Project (SIMEP):** The marine environment around Southampton Island is considered a biological hotspot in the Canadian Arctic. To better understand this ecologically and culturally significant region, University of Manitoba leads a team of researchers from across Canada and Alaska to collect samples for:

- **a. Water Chemistry:** aim is to understand how the properties of the marine water influence animals and plants. We are also interested to know where the water around Southampton Island comes from, how it changes throughout the year, and then where it goes.
- **b. Kelp and other marine “plants”:** goal is to document both near shore and open water primary producers. Kelp was collected in fishing nets and photos of the kelp forests were taken using an underwater camera.
- **c. Sediment (mud from the sea floor):** purpose is to study the ocean history using sediment that accumulated on the sea floor, as well as to study changes in microscopic algae preserved in the sediment.
- **d. Zooplankton (small animals that live in the water):** purpose is to understand what these small animals eat and who is eating them.
- **e. Fish:** objective is to assess marine fish and invertebrate biodiversity in relation to oceanographic conditions and locality around Southampton Island, Nunavut.
Prior to data collection, the SIMEP project was reviewed and approved by Aiviit and Arviq HTOs, the Hamlets of Coral Harbour and Naujaat, the Nunavut Research Institute and DFO.

As part of the larger research, Dr. Kuzyk and Dr. Ehn, sent one research associate (Michelle Kamula) and one PhD student (Kaushik Gupta) on board the MV William Kennedy for the period of 10-22 August 2018 to study the water masses, circulation, and carbon cycling around Southampton Island in northwestern Hudson Bay. The objective of the water masses, circulation, and carbon cycling program (WMCCP) within the larger SIMEP project was to:

i. use chemical characteristics ($\delta^{18}O$, alkalinity, dissolved inorganic carbon (DIC)) to identify water masses and their sources (eg., Hudson Strait and Labrador Sea, Foxe Basin, and Arctic Ocean), allowing for a better understanding of biological productivity;

ii. understand the fundamental processes creating and driving circulation of these water masses in Northwest Hudson Bay and use this information to infer larger scale circulation in the Hudson Bay complex;

iii. use newly collect summer (SIMEP 2018) data of DIC, DOC, and CDOM along with recently collected winter (POLAR 2018) and spring (BaySys 2018) data to better understand and quantify seasonal carbon cycling within the region.

The 2018 summer scientific cruise aboard the MV William Kennedy was an incredible success, even in the face of one of the windiest summers on record. Part of this success can be attributed to the support provided from the communities of Coral Harbour and Naujaat. The next steps in this project will be to finish the sample analyses and plan for next year’s scientific cruise that will involve visiting the north side of the island and hopefully re-visit the south stations already sampled. Part of the planning process will be to visit Coral Harbour and Naujaat this winter to report on findings to date and our summer 2019 plans, while seeking feedback from the communities. I do note that we unfortunately missed a community visit was cancelled this year due to weather, however plans are in place to visit both communities in summer 2019. This project is funded by the MEOPAR Network of Centres of Excellence, Polar Knowledge Canada, and individual grants to team members.

Sea-Ice Environmental Research Facility (SERF): The Sea-ice Environmental Research Facility (SERF) is the first experimental sea-ice facility in Canada. Located on the campus of the University of Manitoba, the main feature of the SERF facility is an outdoor seawater pool (60 feet long, 30 feet wide and 8 feet deep). It is equipped with a movable roof to control snow cover and ice growth, and various sensors and instruments to allow real-time monitoring. The SERF facility also includes a trailer laboratory and a storage building.

The 2018 campaign at SERF began in mid-December 2017 and ended in March 2018. The following three major experiments were carried out during the 2017/18 field season:

- Remote Sensing of Thermodynamic and Geophysical Processes in Experimental Sea Ice (D. Barber, D. Isleifson, and J. Ehn)
- Microplastics in Sea Ice (F. Wang and N. Geilfus)
- GENICE: Microbial Genomics for Oil Spill Preparedness In Canada’s Arctic Marine Environment (G. Stern, D. Barber, C. Hubert, D. Isleifson, and F. Wang)

GENICE: GENICE is a Genome Canada $10.7 M, 4-year project led by Drs. Gary Stern (CEOS) and Casey Hubert (University of Calgary). This large-scale applied research project will utilize the forthcoming Churchill Marine Observatory and its oil-in-sea-ice mesocosms.

GENICE outcomes include:

- Baseline microbial genomics data useful for assessing marine ecosystem resilience and response to hydrocarbon pollution;
• Bioremediation viability case studies;
• Recommendations on technology-based emergency spill response strategies;
• Best practices for successful knowledge transfer and sharing of diverse knowledge types; and
• Mobilized sharing of genomics and bioremediation information for informed decision making and policy development.

Research Activities in 2018: Leads and team members from each GENICE activity (n=26 plus 1 remote participant from Dalhousie University) attended a GENICE project meeting on May 3, 2018 at the Centre for Earth Observation Science (CEOS), University of Manitoba. Representatives from each activity presented a progress update on their research, outreach and field planning. The meeting provided a forum to network face-to-face and integrate ideas for environmental sample acquisition, research objectives, and planning for the next ROC meeting. This gathering was held concurrently with the International Workshop on Climate Change Adaptation Planning for Ports, Transportation Infrastructures, and the Arctic (CCAPPTIA) Workshop, May 3-4, 2018, led by Adolf Ng of the U of Manitoba’s Transport Institute. Gary Stern and Ashley Gaden served on the CCAPPTIA Workshop Planning Committee.

Field sampling for the 2018 season took place on the CCGS Amundsen and on the Arctic Research Foundation ships MV William Kennedy and R/V Martin Bergmann. Sampling from the various ships over the summer season provided a comprehensive suite of samples throughout Hudson Bay, Hudson Strait, Frobisher Bay, Baffin Bay and Cambridge Bay. Sampling details are as follows:

Leg 1 (BaySys; Quebec City to Churchill; May 25 to July 5): GENICE participants: Diana Saltymakova, Nolan Snyder, Pardis Karimi (University of Manitoba); Michael Stone, Oye Adebayo (University of Calgary). Samples were collected at 21 stations, substantially less than originally planned, due to the Amundsen being called away on search & rescue operations, as well as due to ice conditions. For example, ice conditions prevented sampling in eastern Hudson Bay, so most sampling stations were in the western Hudson Bay region (Figure 2.2). From each station, one or more of the environmental sample types of surface sea water (SSW), bottom sea water (BSW), sea-ice (SI) and/or sediments (S) were collected.

Leg 2c (Vulnerable Marine Ecosystems ROV Programs/DFO/ArcticNet; Iqaluit to Resolute Bay; July 24 to August 16): GENICE participants: Anirban Chakraborty, Margaret Cramm, Aprami Jaggi (University of Calgary); Katarzyna Polciwarteck (University of Manitoba). A total of 33 stations were sampled for microbiological analyses (Figure 2.3). Sediment was sampled from 14 stations using a box corer or ROV (remotely operated vehicle) and water was sampled from 30 stations using a CTD-Rosette.
A major success for field sampling this season was acquiring samples from the hydrocarbon seep area, previously identified by the Geological Survey of Canada, near Scott Inlet, Baffin Bay. Visual observation of an active gas seep near Scott Inlet was made using the CCGS Amundsen’s Super Mohawk II remotely operated vehicle (ROV) and this location was defined as Station 0. Video surveys using the ROV at the hydrocarbon seep site and at sites 1 and 5 km away, in the northeast direction, revealed microbial mats morphologically resembling sulfide-oxidizing Beggiatoa. Water sampling followed a three-dimensional transect that included several depths within the water column down to bottom water (7 m above the seabed) overlying the active seep, and four additional bottom water transects 1 and 5 km away from the seep (Figure 2.3). No box cores were collected due to the rocky bottom of the area where seep was identified, but surface sediment was collected using silicone spatulas from some locations.

Figure 2.3. Stations sampled during the CCG Amundsen Leg 2c expedition, July 25 to August 16, 2018.

Chemical Partitioning of Crude Oil in First-Year Ice and its Impact on Sea Ice Geophysics (Results from the 2017 SERF experiment): The purpose of the experiment was to identify the limits of crude oil detection in sea ice and to observe the interactions of crude oil within first-year ice to understand the migration tendencies inside the ice and its influence on the physical properties of the ice. To do this an artificial oil-in-ice mesocosm experiment was conducted at the University of Manitoba Sea-ice Environmental Research Facility (SERF) from February to March, 2017. Before the beginning of the experiment, a curtain was fixed inside the pool in order to control migration of oil through the ice rather than infiltration through the sides of the tank (Firoozy et al., 2018). The experiment was divided into two phases (Figure 11). Phase 1 began with the formation of ice from open artificial seawater. On the third day, 20 L of a light sour crude oil (Tundra Oil and Gas Partnership) was injected under ~6 cm of ice. Within a day after the injection, the oil became encapsulated due to the low ice temperatures (Fingas and Hollebone, 2003). Eight days after, the ice grew an additional 19 cm and the first sampling set, consisting of 9 cores, was taken from the ice. Another two cores were sampled on February 15, after the thaw in which the warmer weather allowed for the migration of crude oil to the ice surface due to an opening of brine channels.

After phase 1, the pool was melted to an open water state with a layer of surface oil (~3-4 cm thick). Phase 2 then began on March 8th, with the commencement of ice formation in the presence of crude oil. By March 14, the ice grew to a thickness of 20 cm and the third sampling set, consisting of 4 cores, was taken for analysis.

Additionally, water samples (~5.2 L each) were taken from the top and bottom depths of the water column during the second sampling set on February 15th. The tank was equipped with a heating coil, a thermistor string, and a temperature data logger. The thermocouple string, frozen into the ice, was used to measure the in-situ ice temperature profile at intervals of 2.5 cm, from top to bottom, every 15 minutes.
Spatial mapping of the oils composition throughout the ice allowed study the movement tendencies of the oil on both a macroscopic (total oil volume) and microscopic (individual chemical components and chemical groups) level. General oil behaviour was deemed to be determined by its concentration in the ice. A higher oil content resulted in an upward migration to the sea ice surface through any available ice channels showing a tendency to perturb the brine concentration. On the other hand, a lower oil content resulted in dissolution in brine and showed a tendency to follow the brine distribution in the cross section. Partitioning of the chemical compounds found in crude oil was observed due to the differences in their physical properties such as solubility, vapour pressure, and density. Subtle differences in these properties between different compounds, homologs, and isomers, were observed to impact their relative movements significantly.

**ArcticNet: a Network of Centres of Excellence:** ArcticNet is a Network of Centres of Excellence (NCE) that brings together scientists and managers in the natural, human health and social sciences with their partners in Inuit organizations, northern communities, government and industry to help Canadians face the impacts and opportunities of climate change and globalization in the Arctic. The NCE network completed its first phase between 2004 and 2011, and was successful in competing for extension that will end in April, 2018. The central objective of ArcticNet is to generate the knowledge and assessments needed to formulate the adaptation strategies and policies that will help northern societies and industries prepare for the full impacts of the transformation of the Arctic. In the reporting year, six ArcticNet projects were led by CEOS research staff: Dr. David Barber led two projects, and Drs. Steven Ferguson, Tim Papakyriakou, Soren Rysgaard, and Gary Stern each led one project.

Geographically, ArcticNet has primarily focused on the coastal regions of the Canadian Arctic environment for several reasons. First, the largest fraction of Arctic and Sub-Arctic Canada is primarily a maritime territory. Second, Canadian Inuit are a coastal maritime people. Third, while continental regions of Arctic Canada (e.g., Mackenzie Basin, Northern Quebec) are relatively well studied, the coastal Canadian Arctic encompasses some of the least studied regions identified in the Northern Climate Exchange-GAP Assessment (2001). Fourth, the logistic support provided by the research icebreaker CCGS *Amundsen*, the central infrastructure of the Network, is limited to coastal marine and terrestrial regions. Temporally, ArcticNet will address the present state of the coastal Canadian Arctic, and try to anticipate the nature and magnitude of the impacts of climate warming on this region at the horizons of 2025, 2050 and 2100. Paleoclimatic studies and Regional Climate Models will reconstruct conditions in the coastal Canadian Arctic over the last several millennia to help cast present observations in a long-term perspective. However, ArcticNet will focus on the short-term evolution of the coastal Canadian Arctic environment and the strategies needed for communities and industries to adapt to the impacts of incoming warming and modernization. Culturally, ArcticNet focuses on the impacts of environmental and societal changes on Inuit-dominated regions and communities that fall within the boundaries of ArcticNet’s geographical domain of research activity.

The scientific program of ArcticNet has been specifically tailored to address the central recommendation of the Northern Climate Exchange Gap Assessment (NCE-GAP) to conduct Integrated Regional Impact Studies (IRISes) in which community level studies are embedded. ArcticNet has developed four highly integrated, multidisciplinary, cross-sector studies of climate change impacts in key regions of the coastal Canadian Arctic. Originally in the form of ‘themes’ during Phase I (2004-2007) of ArcticNet, these four campaigns changed into IRISes for Phase II (2008-2011).

A summary of the geographical focus of the four IRISes is outlined below:
• IRIS 1 focuses on research conducted in the Canadian Western and Central Arctic including the Northwest Territories Inuvialuit region, as well as the Nunavut’s Kitikmeot region. Lead: Dr. G. Stern, Coordinator: Ashley Gaden.
• IRIS 2 focuses on research in the Eastern Arctic. This region is entirely within Nunavut and ranges from Hudson Strait to Alert, including Baffin Island and Ellesmere Island. Coastal Communities of the Kivalliq region of Nunavut and Sanikiluaq are part of IRIS 2.
• IRIS 3 is focused on the Hudson Bay region and includes the coastal regions of Nunavut, Manitoba, and Ontario. The northern reaches of this IRIS include Hudson Strait and Foxe Basin. Lead: Dr. D.G. Barber, Coordinator: Natalie Thériault and Lauren Candlish.
• IRIS 4 is focused on the Eastern Subarctic region. This includes the Nunavik region of Quebec and the Nunatsiavut region of Labrador.

For further details on ArcticNet please go to: [http://www.arcticnet.ulaval.ca](http://www.arcticnet.ulaval.ca).

**Integrated Regional Impact Study of the Western and Central Canadian Arctic (IRIS 1):** IRIS 1 successfully completed the translation of the Synthesis and Recommendations booklet into four Inuit dialects: Uummarmiutun, Siglitun, Inuinnaqtun and Inuktitut (roman orthography and Inuktitut syllabics). The IRIS 1 team with Winnipeg publishing house Relish Design and local printers Premier Printers Ltd published and printed >900 copies of the various languages, including an English-French version (40 pp). Each of the five versions was uploaded to the ArcticNet website ([www.arcticnet.ulaval.ca](http://www.arcticnet.ulaval.ca)) and were initially released at the ArcticNet Annual Scientific Meeting at the RBC Convention Centre, Winnipeg, Dec. 5-9. Addresses for >50 partners and stakeholders in the North and across Canada were confirmed for distribution in the 2017-2018 fiscal year. The IRIS 1 leader (Dr. Gary Stern) and coordinator (Ashley Gaden) participated in the ArcticNet Regional Management Committee meeting in February 2016 to discuss progress and goals for the next 2017-2018 year, including circulating a questionnaire to receive feedback on the 2015 publication of the Regional Impact Assessment of the western and central Canadian Arctic, distributing the Synthesis and Recommendations booklets, and working on a second iteration of the Regional Impact Assessment with the IRIS 1 steering committee.

**Integrated Regional Impact Study of the Hudson Bay Marine Region (IRIS 3):** This ArcticNet Integrated Regional Impact Study (IRIS) for the Greater Hudson Bay Marine Region has been written to summarize the current knowledge available for the coastal and marine environment. This IRIS report incorporates results from scientific studies, traditional knowledge, the perspectives of Inuit and Cree represented through the IRIS steering committee and input from a variety of stakeholders who contributed to the editorial team. The goal of this document is to provide relevant and practical information for regional decision-makers and local communities in an accessible format. The University of Manitoba coordinating and editorial team working to put together the IRIS consists of:

- David Barber – Lead
- Zou Zou Kuzyk – Co-Lead
- Lauren Candlish – Hudson Bay IRIS Coordinator
- Michelle Kamula – Hudson Bay IRIS Assistant Coordinator

A central challenge with the Hudson Bay IRIS is the tremendous diversity of the Hudson Bay Region and its communities, cultures and governance structures. In order to adequately represent this diversity, we are preparing several sections that will be included as Appendices to the document. One of these addresses the legal frameworks (e.g., NLCA, JBNQA, EMR, etc.) that provide the context for governance and environmental management in the various regions around the Bay. Secondly, with help from various committee members, and aided by some examples prepared by Alan Penn for Cree communities, we have prepared “community sketches”, which will help inform the introductory chapter and may be included in full in an appendix. These sketches help to introduce the diversity of
communities within the Hudson Bay system and illustrate also the complexity of the governance structure.

The Hudson Bay IRIS document presently has four sections divided by themes, with topical chapters based on each theme. The introduction is being drafted collaboratively by the University of Manitoba team and the Steering Committee. The topical chapters are at different states of completeness with most having been reviewed by the editorial team and scientific peers. Lauren Candlish, Zou Zou Kuzyk, and Jonathan Andrews organized and conducted a Hudson Bay IRIS session as part of the Hudson Bay Consortium meeting in Chisasibi in November 2016. The meeting was attended by representatives of communities from all over eastern Hudson Bay, including Sanikiluaq, Nunavut; numerous Nunavik communities; and the five coastal Cree communities. The meeting was also attended by representatives of regional, provincial/territorial, federal (e.g. KRG and DFO) and non-profit (e.g. Oceans North, CPAWS) organizations. Our IRIS group presented at the meeting and this was an excellent opportunity to describe the IRIS process and the assessment report (goals, structure, content, timeline) and to solicit feedback from northerners. After presenting, we facilitated a workshop and circulated a survey, both of which generated very useful feedback. Overall, it was an excellent event for establishing connections with and gaining input from community members and organizations.

**Freshwater-Marine Coupling in Hudson Bay: a Study of Winter Estuarine Processes in the Coastal Corridor in Southeast Hudson Bay and Effects of Environmental Change:** The overall goal of this project is to improve our understanding of how river runoff, seawater upwelling and vertical mixing, and the sea ice cycle (formation/melt) interact to modify water masses and circulation in southeast Hudson Bay/eastern James Bay. Hudson Bay is undergoing loss of seasonal sea-ice, increase in freshwater inflow and a shift of inflow from summer to winter from regulated rivers. Southeast Hudson Bay is a point of convergence of the river-water laden coastal current flowing eastward from southwest Hudson Bay and the even more river-water laden outflow from James Bay. Recently Inuit have observed unprecedented rapid freezing of flaw leads and polynyas around the Belcher Islands in SE Hudson Bay, which has led to concern for wildlife that depend on these areas (Gilchrist et al., 2006; Heath and Community of Sanikiluaq, 2011; NTK, 2008).

Scientific information for SE Hudson Bay and NE James Bay is extremely scarce and particularly during the winter period. However, many of the processes occurring in the region are believed to be of key importance not only for physical and chemical processes that couple the terrestrial and marine environments but also a controlling factor for wildlife and human use. For instance, brine rejection associated with rapid sea ice growth in polynyas and flaw leads is believed to produce dense water that sinks and renews oxygen and other properties in the deepest waters of Hudson Bay. Thus, addressing knowledge gaps related to coastal oceanographic conditions particularly in winter is critical in order to have a basis from which to infer the probable effects of the hydroelectric and climate-related changes that are ongoing and also yet to come.

Riverine coastal domains such as that found in SE Hudson Bay are a focal point for environmental change (cf., Carmack et al., 2009), firstly because of their estuarine character, and secondly, because of the influence of the seasonal sea ice growth-melt cycle. Through influences on stratification, freshwater inputs and tidal mixing can alter the onset and rate of sea-ice formation. In turn, sea ice melt represents a second important source of freshwater to Arctic coastal systems, in addition to river water. Both freshwater sources are important in Hudson Bay and both have undergone change due to hydroelectric development and climate change. Freshwater distribution in the coastal corridor in SE Hudson Bay has perhaps been particularly influenced by river regulation because of its proximity to the La Grande River system in northeast James Bay. At the same time, climate-driven changes cannot be ignored. Because Hudson Bay is at the southern margin of the Arctic, it may undergo earlier and more rapid warming due...
to climate change than areas further north. Thus, the Hudson Bay system may represent an important sentinel for climate-related changes coming in future decades to high Arctic areas.

The present study focuses on freshwater distribution and seasonal evolution in SE Hudson Bay. The study was designed to study subsystems within which coastal water masses are modified in winter by distant, large-scale river inflows from massive, regulated rivers (Nelson, La Grande), and compare them to those in which local natural river inflows (Great Whale) dominate the freshwater budget and those in which river inflows are minimal. Secondly, the project was designed to be conducted using a community-driven research framework, implicitly incorporating both scientific observations and the traditional knowledge possessed by our Inuit and Cree research partners. Co-development of knowledge and knowledge exchange have been foundations of the work and are reflected in the nature and timelines of the activities, the nature of the results and the interpretations.

Field Activities:

Early winter observations – January and February 2017: The early winter field campaign involved collecting conductivity-temperature-depth (CTD) profiles of the water column and obtaining water samples for analysis of freshwater tracers and a variety of other analytes (salinity, oxygen isotope ratios ($\delta^{18}O$), dissolved carbon system parameters, dissolved nutrients, suspended solids, particulate organic nitrogen and carbon). We worked from the landfast ice platform around Umuijaq, Inukjuak, Kuujjuarapik/Whapmagoostui, and Chisasibi, accessing sites by skidoo with the support of Inuit and Cree hunters/guides. Community members conducted CTD casts near Sanikiluaq. Participants included Zou Zou Kuzyk, Jens Ehn, Michelle Kamula, Joel Heath, and Misha Warbanski.

At Kuujjuarapik/Whapmagoostui, we also installed two ice-tethered oceanographic moorings (Figure 2.4). Each mooring included one or more CT sensor, an ice-tethered profiler (ITP), and an acoustic Doppler current profiler (ADCP). The mooring deployment was accomplished by Sergei Kirillov and Igor Dmitrenko (CEOS) with support from Zou Zou Kuzyk and Michelle Kamula (CEOS), Inuit guides from Kuujjuarapik, and staff of the Centre Etudes Nordiques (CEN).

At Chisasibi, several ice-tethered moorings were installed to monitor changes in temperature, salinity and turbidity throughout the winter period. The spatially distribution of the mooring array (Figure 2.5) was designed so as to allow investigation of how changes in the offshore water mass, which is strongly influenced by the La Grande River plume, affect properties at inshore (~4 m water depth) eelgrass beds.
Figure 2.4. Image of the study area near Kuujjuarapik and the Great Whale River in January 2017 showing the coastal sea-ice cover, sites of CTD casts (white symbols numbered 1 to 6), and sites of moorings KU17-01 (inshore) and -02 (offshore) (black circles with red fill).

Figure 2.5. Map of the Chisasibi study area showing array of mooring locations during 2016-2018.

Late winter-early spring observations – April 2017: The late winter –early spring field campaign involved collecting CTD profiles of the water column and obtaining water samples for analysis of freshwater...
tracers and a variety of other analytes (salinity, oxygen isotope ratios ($\delta^{18}O$), dissolved carbon system parameters, dissolved nutrients, suspended solids, particulate organic nitrogen and carbon). We repeated the water sampling at Kuujjuarapik/Whapmagoostui and Chisasibi and collected the first set of 2017 water samples at Sanikiluaq. Participants included Zou Zou Kuzyk, Jens Ehn, Michelle Kamula, Joel Heath, Alessia Guzzi, and Misha Warbanski and Inuit and Cree research partners in each community.

Recovery of the ice-tethered oceanographic moorings was attempted at Kuujjuarapik/Whapmagoostui at this time. Mooring KU17-01 (inshore) was successfully recovered but unfortunately mooring KU17-01(offshore) was not. The outer portion of the landfast ice platform including the portion supporting the mooring had been removed. Review of satellite images indicates that major deformation of the landfast ice edge occurred during a major storm in March after which the ice (including that supporting the mooring) was removed. The mooring recovery effort was conducted by Sergei Kirillov and Igor Dmitrenko with support from Michelle Kamula (CEOS), Inuit guides from Kuujjuarapik, and staff of CEN.

Summer observations – July, August, September 2017: The summer field campaign involved collecting CTD profiles of the water column and obtaining water samples for analysis of freshwater tracers and a variety of other analytes (salinity, oxygen isotope ratios ($\delta^{18}O$), dissolved carbon system parameters, dissolved nutrients, suspended solids, particulate organic nitrogen and carbon). We repeated the water sampling at Sanikiluaq, Kuujjuarapik/Whapmagoostui and Chisasibi. Participants included Zou Zou Kuzyk, Jens Ehn, Michelle Kamula, Quinton Fiering (Trent University), Joel Heath, Alessia Guzzi, Chris Peck, and Misha Warbanski and Inuit and Cree research partners in their respective communities.

In Chisasibi, water column profiling and sampling was coordinated with efforts of Dr. Fred Short and his team, who have begun to study eelgrass. Observations of T, S, $\delta^{18}O$, turbidity, total suspended solids, CDOM and dissolved nutrients were collected at several eelgrass beds and coastal areas that once hosted eelgrass but have little to none at the present time. In addition to supporting our oceanographic research questions, the data contribute to a new initiative that is studying the eelgrass beds and associated oceanographic factors in eastern James Bay.

Fall observations – October 2017: In October, 2017, water sampling was accomplished from aboard the Coast Guard Henry Larsen which was conducting a mooring recovery operation in southwest Hudson Bay. Water samples were obtained for the analysis of T, S, CDOM and dissolved nutrients.

Data interpretation and dissemination: In 2017-2018, we also placed emphasis on data interpretation and communication of results. Annie Eastwood completed and defended her Master’s thesis. A manuscript was submitted by PhD candidate Vladislav Petrusevich for publication in Continental Shelf Research and a second manuscript was submitted by Eastwood et al. for publication in Estuaries and Coasts. Undergraduate student Alessia Guzzi completed an Honour’s Thesis project on freshwater and nutrients distribution in SE Hudson Bay (presented at Arctic Change 2017). PhD student Chris Peck began preparing a manuscript on Chisasibi oceanographic results (presented at Arctic Change 2017). Results were presented and discussed in Sanikiluaq and Chisasibi in February 2018.

This project has contributed both directly (e.g., Research Associate salary dollars, contracts for community training and logistical support and IK-MAP development) and indirectly (e.g., provision of oceanographic data to populate IK-MAP), to enhancing capacity within the Arctic Eider Society for supporting environmental stewardship and community-driven research in Hudson Bay and for knowledge mobilization. The Hudson Bay Summit is one example of a successful knowledge mobilization activity to which we have contributed. SIKU provides a second example. These activities and events have garnered a lot of media attention and leverage the dollars invested by this project into building that capacity. Two awards at the Arctic Change conference - the ITK Inuit Recognition Award, which went to AES Board Member Lucassie Arragutainaq (Dec 2017), and the ITK Inuit Partnership of Excellence Award, which went to AES PhD student Megan Sheremata - also were associated with AES.
and the community-driven research network that arose around the oceanographic project in SE Hudson Bay.

The following list highlights some additional knowledge sharing activities.

- Using the Arctic Eider Society’s on-line interactive mapping platform IK-MAP, results of more than 250 oceanographic deployments (e.g., conductivity-temperature-depth (CTD) casts) and five moorings (including continuous observations of temperature, salinity and in places currents) were made available in near-real time to all research partners and the interested public.
- Hands-on training in oceanographic monitoring/sampling methods and general scientific mentoring was completed involving more than 40 Northern research partners and more than 15 youth across five communities.
- Three presentations were made at large meetings that included stakeholders (Manitoba Hydro, Hydro Quebec) and regional or national entities (Cree Nation Government, Parks Canada, Fisheries and Oceans).
- One scientific publication is in review at a journal, a second near submission, and two others in preparation.
- Four presentations were made at scientific conferences.
- We contributed to presentations and discussions and provided scientific context and background for the Hudson Bay Consortium meeting, Montreal, February 2018; this effort is focused on building collaboration and information sharing towards environmental stewardship goals for the greater Hudson Bay/James Bay region.
- Contributed content and leadership towards the Hudson Bay IRIS.

Community-Driven Sea Ice and Ocean Research in the Contrasting Coastal Domains of Hudson Bay:

A research program titled “Community-Driven Sea Ice and Ocean Research in the Contrasting Coastal Domains of Hudson Bay” began its first field campaigns in February and May of 2018. Working closely with communities of Naujaat and Chesterfield Inlet, researchers from CEOS collected sea ice measurements and oceanographic data (CTD profiles and water chemistry) from the land-fast ice in northwestern Hudson Bay. With an objective to compare the northwest region of Hudson Bay to the southeast, Dr. Jens Ehn and PhD student Chris Peck travelled by skidoo with local hunters from Sanikiluaq across an ice bridge that formed between Belcher Islands and mainland Quebec. This ice bridge was an anomaly that has not formed in over 20 years, providing a rare opportunity to collect winter oceanographic data beyond the usual land-fast ice expanse (typically ~5-10 km from land). Outreach and training is an important component of this project. While in the community of Chesterfield Inlet in May 2018, research associate, Michelle Kamula, and MSc. Student Alessia Guzzi, organized a science outreach afternoon with the local high school. The exercise involved high school student travelling out on the sea ice by skidoo and komatik to take part in hands on activities to collect scientific data (https://nunavutnews.com/nunavut-news/chester-teens-drill-for-science/). In Naujaat, training on the use of oceanographic equipment in winter and spring 2018 resulted in the hiring of two Inuk hunters to continue collecting bi-weekly CTD profiles into June, July and August. This project has funding for two years (2017-2019) from Polar Knowledge Canada, and represents collaboration between Centre for Earth Observation Science (University of Manitoba), the Arctic Eider Society, and the communities of Naujaat, Chesterfield Inlet, and Sanikiluaq.

Keeyask GHG Tower Flux Program: A tripod-based eddy covariance (EC) system was installed on the southern bank of the Nelson River, July 12th and 13th, 2017; launching a preliminary monitoring program focusing on greenhouse gas (GHG) source/sink behaviour of subsystems associated with the Nelson River and proposed Keeyask impoundment, both pre- and post-flooding. Site location and system configuration are described below. The purpose of this report is to provide a preliminary
assessment of data resulting from this system. Objectives are to: (i) assess the quality of data acquired from the system in support of flux calculations; (ii) the suitability of the tower location to confirm flux footprint/wind orientation is suitable to capture flux signature from the Nelson River Channel, and background peatland (northerly and southerly winds respectively); and (iii) provide a first look at fluxes from the Nelson channel upstream of the Keeyask work site. The temporary tripod was dismantled September 19th, 2017.

A tripod was placed with EC sensors mounted on a cross arm approximately 3.86 m above the surface (Figure 2.6). The orientation of the sensors should allow us to stratify the data as onshore (from Nelson Channel, Figure 2.7) for northerly winds and off-shore (from shaved boreal peatland) for southerly winds. The tripod itself was located at 56.3291°N, 95.3278°W; between 7-10 m south of the river bank. The system was set up July 12th and 13th, 2017 and visited July 27th, 2017 for data download and instrument maintenance. Instrumentation and tripod was dismantled September 19th, 2017 with the intention to set-up a new tower at a permanent monitoring site. Unfortunately, the new equipment was unsuitable and will be set up at a later date.

Site instrumentation included an EC system, consisting of a 3D sonic anemometer (Gill WindMaster Pro, Hampshire, UK), and open path gas analysers for CO₂ (LI-7500, LICOR, Lincoln, Nebraska) and CH₄ (LI-7700, LICOR, Lincoln, Nebraska). Air temperature and relative humidity were measured using a probe (Vaisala, model HMP45C212, Vantaa, Finland) while solar radiation was measured with a quantum...
sensor (Kipp & Zonen, Delft, Netherlands). Data from the EC sensors were acquired at 10 Hz, and logged in 30 minute files to USB using an on-site logger/interface unit (LI-7550, LICOR, Lincoln, Nebraska). Meanwhile the temperature-relative humidity probe and quantum sensor output were logged by a separate data logger (Campbell Scientific, model CR3000, Edmonton, AB) scanned at 5s intervals, and saved data as 2 minute averages. The site was powered using two 250W solar panels and a battery array composed of 4 6V deep cycle marine batteries connected in series and then in parallel to produce two 12V batteries. Corrections to data and fluxes as well as calculations were applied using EddyPro® (LICOR, Lincoln, Nebraska).

**Manitoba Great Lakes Project (MBGL):** CEOS is a founding member of the Lake Winnipeg Research Consortium (LWRC). The overarching goal of our MBGL Project is to investigate watershed forcing on nutrient chemistry and biology of the three largest lakes in Manitoba: Lakes Winnipeg, Manitoba, and Winnipegosis, and to develop a better understanding of how major nutrients and contaminants move through the freshwater ecosystem associated with these great lakes. The program began with remote sensing studies in Lake Winnipeg (2000–present). In the past, this work has led to a significant publication (McCullough et al., 2012) which demonstrated that increased frequency and extent of flooding in the Red River basin had greater effect on phosphorus loading to Lake Winnipeg than had the previous 25 years (at least) of increased anthropogenic loading by fertilization, intensive animal husbandry and lack of adequate sewage treatment in the watershed. It has also supported major contributions as co-authors in the State of Lake Winnipeg Report and the most comprehensive remote sensing study of algal blooms in Lake Winnipeg to date (Binding et al. 2018). In 2012, CEOS expanded the geographical scope of this research with a new moorings and seasonal water quality sampling program in Lakes Winnipegosis, Waterhen and Manitoba (the upper MBGL) that has continued to the present.

With three moorings recording in situ data, in combination with regularly scheduled water sampling, CEOS and the University of Manitoba are able to:

- take a leadership role in monitoring the health of Manitoba’s freshwater through nutrient and contaminant testing,
- develop an understanding of how nutrients and contaminants move throughout the freshwater ecosystem,
- calibrate and validate optical remote sensing platforms for improved monitoring of sediment and phytoplankton in the MBGL, and
- use this new data to evaluate the anthropogenic impact on Manitoba’s freshwater ecosystem.

This information can be used by government, industry and other stakeholders to improve the health of Manitoba’s freshwater, ensuring the stability of the clean water Manitoba’s Great Lakes provide, and the economic and social infrastructure that have been built upon it.

In 2018, Claire Herbert (supervised by Dr. David Barber) continued her MSc program designed to: 1) develop local calibration and validation of satellite data for phytoplankton monitoring; 2) determine the population structure of the phytoplankton communities; and 3) determine nitrogen fixation by phytoplankton in the MBGL community continued. In the summer of 2018, Dr. Tim Papakyriakou began a multi-year, multi-lake study of carbon flow through the MBGL; he began this program with sampling and instrumental observations this year on three whole lake cruises (spring, summer and fall) in Lake Winnipeg. Three HQP were associated with the project: BSc students Kate Yezhova and Rachel Mandryk, and PDF Dave Capelle, who assumed supervisory responsibilities. In the fall of 2018, Katelyn Rodgers (sup. by Dr. David Barber) began her MSc program to study the relative impacts of environmental and anthropogenic forcing on nutrient export from the MBGL watershed.
Moorings (with instruments recording chlorophyll A, phycocyanin, turbidity, temperature, and pressure) were deployed and recovered in Lakes Manitoba and Waterhen. Water quality data was and analyzed as part of a continuing monitoring program (conductivity, temperature, turbidity, phosphorus, nitrogen, carbon, chlorophyll, total suspended solids) as well as for satellite calibration (αP, CDOM in addition to previous list). Samples for algal and zooplankton identification and for algal toxin analysis were also collected and preserved. Community-based monitoring initiatives in conjunction with the Lake Winnipeg Foundation continued.

References:

Mercury Emissions from Volcanic Sources in Costa Rica: Mercury emissions from volcanic sources remain an unconstrained portion of the global annual flux. To better inform this area of uncertainty, the CEOS team, led by Dr. Feiyue Wang and MSc student Skye Kushner, is conducting comprehensive environmental sampling at two volcanoes in collaboration with researchers from Universidad National de Costa Rica (UNA). Poás volcano, Alajuela province, is one of the most active volcanoes on earth and experiences weekly small eruptions at a hyper acidic lake within the main crater. The most recent major eruption was in April, 2017, and removed a number of previous features in the crater. Turrialba volcano, Turrialba province, is less active than Poás, but the small number of recent eruptions are larger and frequently blanket the capitol city of San Jose in ash.

Full sampling for both volcanoes finished in November 2017 (Figure 2.8), and the past year has involved sample analysis. In all, atmospheric, ash, and water concentrations of mercury have been assessed at both volcanoes. The results of this research are in the process of being published and will represent a major revision in the scientific communities understanding of how volcanoes emit trace gasses. Two new techniques (one active and one passive) have also been validated in volcanic environments, with will allow for other groups to sample in similar environments.

![Figure 2.8. Local researchers from OVSICORI sampling for sulphur on the crater floor of Poas. The main vent, spewing almost 2,000 tons of sulphur dioxide per day is prominent in the background. (Photo credit: S. Kushner)](image)
Through a network made from this volcanic collaboration, CEOS researchers have been advising on best practices related to proper mercury collection with environmental groups at UNA to carry on the mandate of this research after the current project has finished. We have also been active in training a research group with the local parks service in proper mercury collection techniques for water sampling, allowing for a multi-year review of several protected habitats.

**Canadian Watershed Information Network:** The Canadian Watershed Information Network (CanWIN) provides Canadian researchers with a collaborative web-based platform to connect multiple watershed related data repositories and datasets nationwide.

The Canadian Watershed Information Network (CANWIN), formerly the Lake Winnipeg Basin Information Network, is a web-based open access data and information network created by Environment Canada as part of the Lake Winnipeg Basin Initiative under Canada’s Action Plan on clean water. This integrated network will centralize and facilitate the synthesis of terabytes of digital data that are collected each year, and connect with large scale monitoring initiatives aimed at the characterization of hydrological, biogeochemical, geomorphological and ecological dynamics. Data associated with such dynamics have typically been collected and analyzed in isolation, thus preventing truly comprehensive research and environmental management to be achieved across spatial and temporal scales. By harmonizing data and providing interactive visual, statistical and analytical platforms, CanWIN will enable users to gain scientific and operational insights not previously possible, transforming our ability to address critical scientific questions. It was created in order to help address key water quality issues within the Lake Winnipeg Basin.

Mandate: To support research, education, management, policy and evidence based decision-making in the Nelson River Watershed by aiding transparency, building understanding and creating awareness of nutrient and climate related issues in the watershed.

Mission:

- To create an online open access extensible data warehouse to enable data harmonization and integration of site specific datasets (limited by space and time) with broader geographic datasets (watershed, provincial and national scale);
- To communicate key research findings in plain language to reach the broadest possible audience;
- To the greatest degree possible, through the online data repository, provide open access to research data and reports in non-proprietary formats; and
- Use ethical data sharing methods to address unique key stakeholders needs and privacy concerns (e.g. Inuit and First Nations) for information while finding ways to share and integrate Traditional Knowledge and Western Science

In 2012 management of the network transferred to the University of Manitoba in the Clayton H. Riddell Faculty of Earth, Environment and Resources within the Centre for Earth Observation Science (CEOS). As part of two major ecosystem initiatives (Watershed Systems Research Program and the Canadian Consortium for Arctic Data Interoperability [CCADI]), CanWIN is a key component in science communication.

Since its inception, CanWIN has expanded its mandate to house Arctic research data and has become a founding member of the Canadian Consortium for Arctic Data Interoperability (CCADI; www.ccadi.ca). The Consortium represents a critical mass of top academic researchers from six institutions including CEOS and University of Manitoba, which are home to many of Canada’s Arctic scholars, as well as Inuit research organizations, federal agencies, and the non-profit sector. All partners have reputations for excellence as collectively demonstrated by hundreds of grants and publications across a spectrum of
Arctic marine, terrestrial, social sciences, geospatial and computing sciences. The Consortium has decades of experience working with complex (e.g. TK, geospatial, genomics) and dynamic (e.g., sensor data, community-based monitoring) data, and have the common goal of providing ethically open, accessible, and comprehensive digital Arctic resources to the broadest possible audience. CCADI aims to advance collaboration, nationally and internationally, through development of an integrated Canadian arctic data management system that facilitates information discovery, establishes metadata and data sharing standards, enables interoperability among existing data infrastructures, and is accessible to the broadest possible audience of users.

**Outreach and Education**

In addition to research programs, CEOS also invested significant support to a number of outreach initiatives in 2017-18, which involved significant graduate student support.  These activities included:

**Schools on Board Program** (Coordinator: Michelle Clyde): The Schools on Board (SonB) program is a highly successful outreach program of ArcticNet based out of the University of Manitoba. Since 2004, SonB has been delivering unique educational outreach programs that focus on bringing Arctic System Science and Climate Change research to students in Canada and around the world. The main component of this program was the Arctic field program that took small teams of high school students and teachers on board the CCGS *Amundsen* to experience and participate in ArcticNet’s annual scientific expeditions. Over the past 14 years, students from across Canada (north and south) and from other nations (through two international field programs) have participated in over 13 cruises throughout the Canadian Arctic.

The 2017 field program took place during Leg 2 of the ArcticNet cruise (July 6-13, 2017). This program was a pilot initiative targeting northern youth ages 19-29 and was designed differently in order to encourage participants to work more closely with scientists in one-on-one scenarios. This included bringing only a small number of participants (4 in total; Figure 2.9) and an instructor from the Environmental Technology Program from the Nunavut Arctic College. While on board the CCGS *Amundsen*, participants were involved in a variety of sampling activities and a variety of lectures/workshops delivered by scientists on board, including net deployments and sorting sampling in the zooplankton lab, box core deployment and subsampling, water sampling from the rosette, and chlorophyll a filtration. In addition to the science, students were fully immersed in all aspects of life on the ship and were integrated with the science team. The CCGS *Amundsen* crew also interacted with students by providing the necessary safety briefings, as well as informal discussions regarding navigation and different jobs in the Coast Guard. A formal presentation was delivered by Captain Claude Lafrance and a tour of the helicopter by Dick Morissette was also provided to the participants. The objective of this pilot project was to adapt the SonB program to create a model for inspiring and mentoring northern youth and facilitating their future engagement in Arctic climate change research.
Science Rendezvous: Science Rendezvous is a national annual festival that takes science out of the lab and to the general public. It is one of Canada’s largest celebrations of the amazing feats of science and engineering. The University of Manitoba and the Faculty of Science hosted the event on May 13, 2017, engaging adults and children in a day of free fun and discovery. Graduate students and scientists from CEOS participated in the event, setting up an Arctic Field Camp display furnished with a tent and supplies used in the field, to illustrate to the kids how Arctic research is done. There were also a number of hands-on learning stations that explained to kids the importance of the Arctic in a fun and entertaining way. Some of the activities revolved around:

- Colouring different Arctic species; exploring the Arctic foodweb
- Blubber glove; investigate the importance of blubber on marine mammals
- Difference between freshwater and salt water
- Demonstration of field equipment used to sample sea ice (Figure 2.10)
- Microscope to show different components of ice and phytoplankton/zooplankton
- There was also the appearance of a polar bear (Figure 2.11).
Arctic Science Day: Arctic Science Day focuses on bringing Arctic scientists and high school students together in an outdoor learning environment at Fort Whyte Alive, a nationally acclaimed outdoor education facility in Winnipeg. Scientists demonstrate and involve students in sampling techniques while communicating the importance of conducting research in the Arctic. Students are introduced to different aspects of Arctic research, including the following themes:

- Snow and ice sampling
- Contaminants in snow, water and biota
- Atmospheric sciences
- Surface energy budget and albedo
- Remote sensing
- Oceanography
- Arctic people and their environment

On March 8, 2018, more than 150 middle and senior year students and educators from approximately 10 schools throughout Manitoba attended the event. A team of 26 graduate students and scientists from CEOS created nine different stations that included hands-on activities and demonstrations from a variety of disciplines:

**High School:**
- Archaeology
- Ice cores
- Sea ice biology/ice optics
- Contaminants
- Oceanography
- Marine Mammals

**Middle Years:**
- Marine mammals
- Ice and water sampling
- Oil spill station

Expedition Churchill: In April 2016, the Expedition Churchill: Gateway to Arctic Research project was initiated. This is a major outreach project with a budget of approximately $800,000 (cash and in-kind). CEOS partnered with the University of Manitoba, Town of Churchill, Churchill Northern Studies Centre (CNSC), VIA Rail Canada, Travel Manitoba and Assiniboine Park Zoo – Journey to Churchill. This project is a creative public education and outreach campaign intended to highlight CEOS/UM major programs and partner projects operating within the geographic scope of Hudson Bay to: (i) enhance public understanding and interest in the northern system, including sensitives and implications of climate change; (ii) promote UM collaborations with the Town of Churchill, Journey to Churchill, CNSC and
Travel Manitoba; (iii) enhance visitor experience in transit to and within Churchill; (v) promote community engagement in Churchill; and (iv) engage with public interest in climate change research and inspire a greater sense of stewardship and sustainable development of the North.

There are several aspects to this project. Firstly an e-book that highlights the physical, biological and social aspects of the Hudson Bay region was completed. It is available for download through Apple Itunes and Google Play. Secondly, dining cars for the VIA Rail train running from Winnipeg to Churchill are wrapped with images highlighting the Hudson Bay region. These cars will also have education displays including table top interactive material. The final component of the project includes kiosks that will have the e-book accessible to the general public. These kiosks will be situated at locations in Winnipeg associated with partners on this project (i.e. Assiniboine Zoo and Via Train Station), as well as in the Town of Churchill and Churchill Northern Studies Centre.

**Miscellaneous Outreach Events**

Members of CEOS were also involved in a number of other, smaller outreach events, including:

- On March 12, 2018, staff and faculty at CEOS conducted some hands-on learning experiments for the children at the Campus Children’s Centre. Kids aged 3 and 4 years old were given demonstrations on salinity, temperature and basic oceanography.
- CEOS was also asked to provide participants in Leadership Winnipeg, a 10-session leadership program a tour of the facilities. This occurred on March 16, 2018.
- Researchers on board the Amundsen in the spring/summer of 2017 were asked to participate in a documentary called “The Breaking Ice” produced by 360° Project. The screening of the film occurred at the end of February in the Hochheim Theatre in Wallace. The trailer for the film can be viewed at https://www.thebreakingicefilm.com.

**Isaaffik:** As part of our participation in the Arctic Science Partnership, members of CEOS are included in Isaaffik (isaaffik.org), which is a Greenlandic word for gateway. This is a user driven web-based platform supporting research and collaboration. The Arctic is undergoing immense and rapid transformations with climate change as the driving force increasing the demand for scientific research and cooperation across borders. ISAFFIK Arctic Gateway creates a platform for collaboration, inspiration, synergies and creativity for research, education, consultancy and logistics. Research projects and metadata, field courses offered by faculty in CEOS, as well as our outreach events are posted to this platform to engage a larger audience in the work being conducted at CEOS.

**Media**

CEOS is currently active on Facebook (https://www.facebook.com/centreforearthobservationscience/), Twitter (https://twitter.com/CeosUofm) and Instagram (https://www.instagram.com/ceos_uofm/?hl=en) with new posts daily. In addition, our posts are also available on the ASP website (www.asp-net.org/news), Facebook (https://www.facebook.com/ArcticSciencePartnership/) and Twitter accounts (https://twitter.com/aspscience).

A number of CEOS related projects have been highlighted on UM Today, as well as local and national media outlets. A partial list of these news stories is available below.

**UM Today News**

*Expedition Churchill* (November 2018) http://news.umanitoba.ca/expedition-churchill-a-gateway-to-arctic-research/
Governor General visits CEOS (November 2018) http://news.umanitoba.ca/governor-general-to-visit-campus/

How we solved an Arctic mercury mystery (October 2018) http://news.umanitoba.ca/the-conversation-how-we-solved-an-arctic-mercury-mystery/

Bundling up for summer (September 2018) http://news.umanitoba.ca/bundling-up-for-summer/

First research vessel dedicated to Hudson Bay will explore previously understudied Arctic regions (July 2018) http://news.umanitoba.ca/first-research-vessel-dedicated-to-hudson-bay-will-explore-previously-understudied-arctic-regions/


Wpg Free Press: Arctic scientists take students into the field (March 2018) http://news.umanitoba.ca/wpg-free-press-arctic-scientists-take-students-into-the-field/


David Barber receives honorary degree from Laval (December 2017) http://news.umanitoba.ca/david-barber-receives-honorary-degree-from-laval/ 


Monster discovered in Canadian Arctic (October 2017) http://news.umanitoba.ca/monster-discovered-in-canadian-arctic/ 


Vote: SIKU mapping platform a finalist for Google challenge (March 2017) http://news.umanitoba.ca/shifting-arctic-sea-ice-inspires-social-media-mapping-platform/ 

Manitoba and Genome Canada invest in research in Canada’s Arctic (January 2017) http://news.umanitoba.ca/manitoba-and-genome-canada-invest-in-research-in-canadas-arctic/ 

Winnipeg Free Press 

Manitoba MP attending Churchill summit to carve out town’s role once railway repaired (June 2018)

U of M prof, Calgary research partner get $4M for Arctic oil-spill research (January 2017)
https://www.winnipegfreepress.com/local/u-of-m-prof-calgary-research-partner-get-4m-for-arctic-oil-spill-research-410858875.html

Winnipeg Sun
Interactive e-book hopes to put spotlight on Churchill (November 2018)

CTV News
Hazardous conditions caused by climate change put UofM Arctic research study on ice (June 2017)
https://winnipeg.ctvnews.ca/hazardous-conditions-caused-by-climate-change-put-u-of-m-arctic-research-study-on-ice-1.3455822

CBC
Made-in-Manitoba carbon tax falls short, says Arctic climate change expert (November 2017)

Climate change researchers cancel expedition because of climate change (June 2017)

National Post
With a key Arctic research project set to close in 2018, Trudeau’s science minister considers next steps (January 2017)

Global News
Manitoba’s Arctic science celebrated in new Expedition Churchill campaign (November 2018)

Canadian climate change study cancelled because of climate change (June 2017)

Canada’s National Observer
Hazardous conditions caused by climate change put Arctic research study on ice (June 2017)

Nunavut News
All aboard for scientific research (June 2018) https://nunavutnews.com/nunavut-news/all-aboard-for-scientific-research/

AGU 100
Arctic Sea Ice Becoming A Spring Hazard For North Atlantic Ships (March 2018)
University of Waterloo

*Environment alumnus named to the Order of Canada* (January 2017)

**Videos**

*David Barber fra University of Manitoba, Canada* (November 2017)
https://www.youtube.com/watch?v=xYwy2aGf4bc
3.0 SOURCES OF FUNDING AUTHORIZED FOR THE PAST YEAR

EXTERNAL GRANTS AND CONTRACTS

The majority of funding to hire staff and purchase equipment related to research conducted in the Centre is provided through research grants acquired by individual Principal Investigators. In the 2017-18 fiscal year, the Centre managed more than $4.6 million in research grants. Table 3.1 lists the research grants held during the 2017-18 fiscal year by Principal Investigator. The largest research grants were the Canada Excellence Research Chair ($1.4 million), ArcticNet ($555,381), Genome Canada ($484,135) and Canada Research Chairs ($481,180) (Figure 3.1).

**Table 3.1:** Research grants obtained or held during the 2017-18 fiscal year. These funds were managed by CEOS administrative staff.

<table>
<thead>
<tr>
<th>Principal Investigator</th>
<th>Fund#</th>
<th>Research Project</th>
<th>Amount (2017-2018)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barber</td>
<td>301912</td>
<td>CRC NSERC 950-206242 Sal Barber</td>
<td>$42,700.00</td>
</tr>
<tr>
<td>Barber</td>
<td>301913</td>
<td>CRC NSERC 950-206242 Res Barber</td>
<td>$157,300.00</td>
</tr>
<tr>
<td>Barber</td>
<td>317525</td>
<td>ANet DB Sea-Ice 2018</td>
<td>$83,806.00</td>
</tr>
<tr>
<td>Barber</td>
<td>317528</td>
<td>NSERC RGPIN 04950-15 Barber</td>
<td>$41,000.00</td>
</tr>
<tr>
<td>Barber</td>
<td>317545</td>
<td>NSERC RGPNS 305426-15 Barber</td>
<td>$20,000.00</td>
</tr>
<tr>
<td>Barber</td>
<td>317602</td>
<td>ANet DB Iris - 3 Coordinator</td>
<td>$70,000.00</td>
</tr>
<tr>
<td>Barber</td>
<td>317643</td>
<td>MB Hydro/Barber-NSERC 317696</td>
<td>$230,000.00</td>
</tr>
<tr>
<td>Barber</td>
<td>319372</td>
<td>Research Manitoba MCEF Barber Anet1</td>
<td>$14,876.28</td>
</tr>
<tr>
<td>Barber</td>
<td>319646</td>
<td>Lake Wpg Fdn/Barber</td>
<td>$6,000.00</td>
</tr>
<tr>
<td>Barber</td>
<td>319766</td>
<td>Genome GENICE/sub319637/Barber</td>
<td>$75,000.00</td>
</tr>
<tr>
<td>Barber</td>
<td>320159</td>
<td>CFI-IOF #33089 Barber</td>
<td>$108,600.00</td>
</tr>
<tr>
<td>Barber</td>
<td>320172</td>
<td>Mitacs Barber IT09957</td>
<td>$30,000.00</td>
</tr>
<tr>
<td>Barber</td>
<td>320406</td>
<td>ANet DB IRIS-3 Regional Meeting</td>
<td>$15,000.00</td>
</tr>
<tr>
<td>Barber</td>
<td>320546</td>
<td>CFI MSI 35560 Barber</td>
<td>$225,000.00</td>
</tr>
<tr>
<td>Barber</td>
<td>320661</td>
<td>ECCC Barber GCXE18P133</td>
<td>$8,970.00</td>
</tr>
<tr>
<td>Barber</td>
<td>320704</td>
<td>EC Barber GCXE18P126</td>
<td>$50,000.00</td>
</tr>
<tr>
<td>Dmitrenko</td>
<td>316354</td>
<td>NSERC RGPIN 03606-14 Dmitrenko</td>
<td>$37,000.00</td>
</tr>
<tr>
<td>Ehn</td>
<td>315105</td>
<td>NSERC RGPIN.435373-13 Ehn</td>
<td>$28,000.00</td>
</tr>
<tr>
<td>Ehn</td>
<td>315131</td>
<td>NSERC RGPNS/444872-13 Ehn</td>
<td>$17,500.00</td>
</tr>
<tr>
<td>Ehn</td>
<td>317738</td>
<td>ANet Ehn 3.6 Hudson Bay</td>
<td>$18,000.00</td>
</tr>
<tr>
<td>Ehn</td>
<td>319906</td>
<td>MEOPAR Ehn 1-02-03-027.3</td>
<td>$3,000.00</td>
</tr>
<tr>
<td>Ehn</td>
<td>320372</td>
<td>Polar Knowledge Cda Ehn NST17180023</td>
<td>$88,320.00</td>
</tr>
<tr>
<td>Ehn</td>
<td>320439</td>
<td>MEOPAR Ehn Polar 1-02-03-027.3</td>
<td>$3,000.00</td>
</tr>
<tr>
<td>Galley</td>
<td>317492</td>
<td>NSERC RGPIN 03842-15 Galley</td>
<td>$20,000.00</td>
</tr>
<tr>
<td>Kuzyk</td>
<td>318545</td>
<td>Government of Nunavut/Kuzyk</td>
<td>$103,351.07</td>
</tr>
<tr>
<td>Kuzyk</td>
<td>320279</td>
<td>MEOPAR Kuzyk 1-02-02-013.6</td>
<td>$15,800.00</td>
</tr>
<tr>
<td>Kuzyk</td>
<td>320565</td>
<td>UofQuebec at Rimouski/Kuzyk</td>
<td>$25,200.00</td>
</tr>
<tr>
<td>Loseto</td>
<td>317544</td>
<td>ANet Loseto Knowledge Co-Production</td>
<td>$80,200.00</td>
</tr>
<tr>
<td>Loseto</td>
<td>319830</td>
<td>ANet Loseto Training Fund MacMillan</td>
<td>$1,031.00</td>
</tr>
<tr>
<td>Loseto</td>
<td>319939</td>
<td>ANet Loseto Training Fund Worden</td>
<td>$1,365.00</td>
</tr>
<tr>
<td>Loseto</td>
<td>320025</td>
<td>NSTP/2017-2018/Loseto/MacMillan</td>
<td>$4,200.00</td>
</tr>
<tr>
<td>Loseto</td>
<td>320028</td>
<td>NSTP/2017-2018/Loseto/Scharffenberg</td>
<td>$4,200.00</td>
</tr>
<tr>
<td>Loseto</td>
<td>320030</td>
<td>NSTP/2017-18/Loseto/Worden</td>
<td>$4,200.00</td>
</tr>
<tr>
<td>Michel</td>
<td>315710</td>
<td>NSERC RGPIN 327416-13/Michel</td>
<td>$21,600.00</td>
</tr>
<tr>
<td>Name</td>
<td>Project ID/Description</td>
<td>Amount</td>
<td></td>
</tr>
<tr>
<td>-----------</td>
<td>------------------------------------------------------------</td>
<td>--------------</td>
<td></td>
</tr>
<tr>
<td>Mundy</td>
<td>NSERC RGPIN/418397 -13 Mundy</td>
<td>$27,000.00</td>
<td></td>
</tr>
<tr>
<td>Mundy</td>
<td>NSERC RGPNS/424231-13 Mundy</td>
<td>$15,000.00</td>
<td></td>
</tr>
<tr>
<td>Mundy</td>
<td>MEOPAR Mundy 2-02-03-005.6</td>
<td>$10,500.00</td>
<td></td>
</tr>
<tr>
<td>Mundy</td>
<td>MEOPAR Mundy 1-02-03-027.1</td>
<td>$40,310.00</td>
<td></td>
</tr>
<tr>
<td>Mundy</td>
<td>NSTP/2017-2018/Mundy/Dalman</td>
<td>$3,100.00</td>
<td></td>
</tr>
<tr>
<td>Mundy</td>
<td>NSTP/2017-2018/Mundy/Pogorzelec</td>
<td>$4,200.00</td>
<td></td>
</tr>
<tr>
<td>Mundy</td>
<td>Research Manitoba MCEF Mundy 2017</td>
<td>$7,455.00</td>
<td></td>
</tr>
<tr>
<td>Mundy</td>
<td>UofW/subfund Mundy</td>
<td>$27,216.50</td>
<td></td>
</tr>
<tr>
<td>Mundy</td>
<td>MOPAR Mundy Polar 1-02-03-027.1</td>
<td>$39,000.00</td>
<td></td>
</tr>
<tr>
<td>Mundi</td>
<td>Resolute-Arctic-ICE</td>
<td>$16,000.00</td>
<td></td>
</tr>
<tr>
<td>Papakyriakou</td>
<td>ANet TP Marine Geochemistry 2018</td>
<td>$40,721.00</td>
<td></td>
</tr>
<tr>
<td>Papakyriakou</td>
<td>MB Hydro/G307/Papakyriakou</td>
<td>$65,000.00</td>
<td></td>
</tr>
<tr>
<td>Papakyriakou</td>
<td>ANet TP Training Funds 2017-2018 Burgers</td>
<td>$3,815.00</td>
<td></td>
</tr>
<tr>
<td>Rysgaard</td>
<td>Travel &amp; Expense - SR</td>
<td>$2,244.00</td>
<td></td>
</tr>
<tr>
<td>Rysgaard</td>
<td>CERC NSERC Sal 214902 Rysgaard</td>
<td>$250,000.00</td>
<td></td>
</tr>
<tr>
<td>Rysgaard</td>
<td>CERC NSERC Res 214902 Rysgaard</td>
<td>$1,150,000.00</td>
<td></td>
</tr>
<tr>
<td>Rysgaard</td>
<td>ANet SR Sea-Ice 2018</td>
<td>$35,000.00</td>
<td></td>
</tr>
<tr>
<td>Stern</td>
<td>Overhead - Stern</td>
<td>$8,598.00</td>
<td></td>
</tr>
<tr>
<td>Stern</td>
<td>NSERC RGPIN 06319-14 Stern</td>
<td>$43,000.00</td>
<td></td>
</tr>
<tr>
<td>Stern</td>
<td>ANet Stern Marine Contaminants</td>
<td>$101,443.00</td>
<td></td>
</tr>
<tr>
<td>Stern</td>
<td>ANet GS IRIS-1 Coordinator</td>
<td>$85,000.00</td>
<td></td>
</tr>
<tr>
<td>Stern</td>
<td>Genome Canada/GENICE/Gary Stern</td>
<td>$409,135.00</td>
<td></td>
</tr>
<tr>
<td>Stern</td>
<td>INAC Stern NGMP EC41 2016-17</td>
<td>$119,848.00</td>
<td></td>
</tr>
<tr>
<td>Wang</td>
<td>CRC Chair Operating - FW</td>
<td>$81,180.00</td>
<td></td>
</tr>
<tr>
<td>Wang</td>
<td>ANet Wang Marine Contaminants</td>
<td>$20,000.00</td>
<td></td>
</tr>
<tr>
<td>Wang</td>
<td>NSERC RGPIN 06000-16 Wang</td>
<td>$61,000.00</td>
<td></td>
</tr>
<tr>
<td>Wang</td>
<td>NSERC RGPNS 488988-16 Wang</td>
<td>$23,000.00</td>
<td></td>
</tr>
<tr>
<td>Wang</td>
<td>NSERC RGPNS 492941-16 Wang</td>
<td>$40,000.00</td>
<td></td>
</tr>
<tr>
<td>Wang</td>
<td>CRC # 950-231031, Sal Wang</td>
<td>$105,780.00</td>
<td></td>
</tr>
<tr>
<td>Wang</td>
<td>CRC # 950-231031, Res Wang</td>
<td>$94,220.00</td>
<td></td>
</tr>
<tr>
<td>Wang</td>
<td>NSERC NETLI 514660-17 Wang</td>
<td>$25,000.00</td>
<td></td>
</tr>
<tr>
<td>Wang</td>
<td>Intl. Union Conservation Nature/Wang</td>
<td>$56,565.60</td>
<td></td>
</tr>
<tr>
<td>Wang</td>
<td>Sea ice Research Facility Income</td>
<td>$20,000.00</td>
<td></td>
</tr>
<tr>
<td>Wang</td>
<td>Soil/Water Testing</td>
<td>$5,000.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total:</strong></td>
<td><strong>$4,689,550.45</strong></td>
<td></td>
</tr>
</tbody>
</table>
Graduate students affiliated with the Centre were also successful in acquiring research funding through two independent sources. Five graduate students received funding through the Northern Studies Training Program (NSTP) to support research activities in the North (Table 3.2). The purpose of this program is to support Canadian graduate students conducting research in the north by providing supplementary funds to help offset some of the high costs associated with Arctic research. In 2017/18 the total support received through NSTP was $19,900.

**Table 3.2:** Northern Studies Training Program received by students in CEOS for research in 2017/18

<table>
<thead>
<tr>
<th>Student</th>
<th>Advisor</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>K. MacMillan</td>
<td>L. Loseto</td>
<td>$4,200.00</td>
</tr>
<tr>
<td>K. Scharffenberg</td>
<td>L. Loseto</td>
<td>$4,200.00</td>
</tr>
<tr>
<td>E. Worden</td>
<td>L. Loseto</td>
<td>$4,200.00</td>
</tr>
<tr>
<td>L. Dalman</td>
<td>C.J. Mundy</td>
<td>$3,100.00</td>
</tr>
<tr>
<td>N. Pogorzelec</td>
<td>C.J. Mundy</td>
<td>$4,200.00</td>
</tr>
</tbody>
</table>

In addition to NSTP funding, three graduate students in CEOS were successful in receiving ArcticNet Training Funds (Table 3.3). This program helps to support the training of graduate students who wish to participate in national and international field schools, courses or institutes by covering 75% of the costs.
to attend these training programs. In 2017/18, the total support received through the ArcticNet Training Fund was $5877.00.

**Table 3.3: ArcticNet Training Fund received by students in CEOS for training opportunities in 2017/18**

<table>
<thead>
<tr>
<th>Student</th>
<th>Advisor</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>K. MacMillan</td>
<td>L. Loseto</td>
<td>$1,031.00</td>
</tr>
<tr>
<td>E. Worden</td>
<td>L. Loseto</td>
<td>$1,031.00</td>
</tr>
<tr>
<td>T. Burgers</td>
<td>T. Papakyriakou</td>
<td>$3,815.00</td>
</tr>
</tbody>
</table>

**ENDOWMENT AND/OR TRUST INCOME**

Every year, students who demonstrate outstanding leadership and/or excellence in Arctic research are awarded the V.E. Barber Memorial Fellowship in Arctic Research. This award was established to honor V.E. Barber, a strong supporter of science and an amateur historian and naturalist. The fund was established through monies raised from the sale of the book *Two Ways of Knowing* written as part of the International Polar Year – Circumpolar Flaw Lead (IPY-CFL) project in 2007-08. In 2017/18, 4 students were awarded this fellowship (Table 3.4).

**Table 3.4: 2017/18 recipients of the V.E. Barber Memorial Fellowship in Arctic Research**

<table>
<thead>
<tr>
<th>Student</th>
<th>Advisor</th>
</tr>
</thead>
<tbody>
<tr>
<td>J. Andrews</td>
<td>D. Barber</td>
</tr>
<tr>
<td>K. Kenyon</td>
<td>D. Barber/S. Ferguson</td>
</tr>
<tr>
<td>A. Delaforge</td>
<td>C.J. Mundy</td>
</tr>
<tr>
<td>A. Eastwood</td>
<td>ZZ. Kuzyk</td>
</tr>
</tbody>
</table>

**UNIVERSITY SUPPORT**

The University of Manitoba and the Clayton H. Riddell Faculty of Environment, Earth, and Resources has provided support to the Centre through salary dollars, capital equipment and space.

*Salary:* The University and Faculty support the Centre through salary dollars for a number of positions including a stipend for Executive Director (in 2018 this also included dollars for a sessional instructor to take over some of the teaching responsibilities from the new Executive Director), Research Associate to assist with the management of equipment and AESES support staff to work with the Director in the overall operation of the Centre.

*Capital Equipment:* In the summer of 2018, CEOS renovated two graduate student rooms (463 and 467 Wallace). This was required to accommodate the large number of graduate students in CEOS. With the renovations, we were able to double the offices available to graduate students. These renovations involved the purchase and installation of approximately 37 desks between the two rooms (Figure 3.2).
Figure 3.2. A photo of the renovated graduate room on the 4th floor of Wallace (463 Wallace).

Space: As of November 2018, CEOS occupies space in the Wallace Building, and on site at the Sea-ice Environmental Research Facility (Table 3.5). This includes offices, lab space and storage space required to conduct the research as part of the Centre. (Note: this does not include office/lab space by academic staff in other departments such as Anthropology, Engineering and Soil Science). In spring/summer of 2018, the university provided an additional 100 m² of space in the basement of Wallace to CEOS. This space was originally used by Central Administration and Physical Plant to store miscellaneous furniture and other items. A chain link fence (shown in Figure 3.3) was moved in order to accommodate this request for additional storage space.

Table 3.5: Space occupied by CEOS

<table>
<thead>
<tr>
<th>Location</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>4th Floor Wallace</td>
<td>770 m²</td>
</tr>
<tr>
<td>5th Floor Wallace</td>
<td>1939 m²</td>
</tr>
<tr>
<td>Basement of Wallace (room 126A)</td>
<td>193 m²</td>
</tr>
<tr>
<td>SERF</td>
<td>3190 m²</td>
</tr>
</tbody>
</table>

Figure 3.3. CEOS new storage space in the basement of Wallace.
4.0 Financial Stability

The annual expenditures of CEOS for the 2017/18 fiscal year are listed in Table 4.1. In 2017/18, more than 80% of the expenditures came from two categories; Salaries and Materials, Supplies and Services (Figure 4.1). The salary costs related to the stipend for the Director, as well as partial salary for the operations manager for the Centre. This person oversees all aspects of equipment required to operate at the high-level of research. These expeditures excludes the costs supported by faculty members through individual research grants. These costs support the hiring of technical, administrative and research staff, as well as equipment.

**Table 4.1:** Annual expenditures of CEOS for the 2017/18 fiscal year.

<table>
<thead>
<tr>
<th>Category of Expenditures</th>
<th>YTD Total</th>
<th>% of Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salaries</td>
<td>$23,537.61</td>
<td>25.4%</td>
</tr>
<tr>
<td>- Academic Salaries ($23,503.88)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Support Salaries ($2.43)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Student Wages ($31.30)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benefits</td>
<td>$3,871.91</td>
<td>4.2%</td>
</tr>
<tr>
<td>Health and Education Levy</td>
<td>$502.56</td>
<td>0.5%</td>
</tr>
<tr>
<td>Travel and Conferences</td>
<td>$1,058.87</td>
<td>1.1%</td>
</tr>
<tr>
<td>Materials, Supplies and Services</td>
<td>$53,603.09</td>
<td>57.8%</td>
</tr>
<tr>
<td>Professional and External Services</td>
<td>$2,581.38</td>
<td>2.8%</td>
</tr>
<tr>
<td>Utilities, Taxes and Insurance</td>
<td>($32.00)</td>
<td></td>
</tr>
<tr>
<td>Capital Asset Acquisitions</td>
<td>$5,687.55</td>
<td>6.1%</td>
</tr>
<tr>
<td>Repairs and Maintenance</td>
<td>$1,844.60</td>
<td>2%</td>
</tr>
<tr>
<td>Fund Transfers Out</td>
<td>$64.61</td>
<td>0.1%</td>
</tr>
</tbody>
</table>
Figure 4.1. Chart showing expenditures for the 2017/18 fiscal year by category.

- Salaries, $23,537.61
- Benefits, $3,871.91
- Health and Education Levy, $502.56
- Travel and Conferences, $1,058.87
- Materials, Supplies and Services, $53,603.09
- Professional and External Services, $2,581.38
- Capital Asset Acquisitions, $5,687.55
- Repairs and Maint., $1,844.60
- Fund Transfers Out, $64.61

*Figure 4.1.* Chart showing expenditures for the 2017/18 fiscal year by category.
5.0 Centre’s Objectives

In 1994, CEOS officially became a research centre of excellence at the University of Manitoba. Over the course of the past 24 years, the Centre has undergone periods of rapid change in terms of funding and staffing. However over this period, the overall objective of the Centre has remained consistent – “to research, preserve and communicate knowledge of Earth system processes using the technologies of Earth Observation Science”. The research conducted by faculty and staff at the Centre has become more collaborative and multidisciplinary working on many regions around the world; however the main focus on Arctic marine system science has and is a unifying theme of our activity. This long period of focus on the core objective has made CEOS one of the national and international research centres on Arctic system science, as exemplified by the identification of this research as one of the research themes in the Strategic Plan at the University of Manitoba, and the appointment of numerous research chairs (including CRC Tier 1 Chairs - Drs. David Barber and Feiyue Wang as CRC Tear 1, Canada Excellence Research Chair - Dr. Soren Rysgaard, and Senior Canada-150 Research Chair - Dr. Julienne Stroeve).

CEOS was also awarded the opportunity to submit a full proposal for a new CERC. If awarded, this new chair will expand the objective of the Centre to include coupling the marine system of the Arctic with freshwater input from the glaciers.

In the early autumn of 2018, CEOS held a one-day retreat at Fort Whyte Alive. All research and administrative/technical staff at CEOS were invited to participate in this retreat, which was lead by the members themselves, rather than the directors. This retreat occurred at the beginning of another period of significant change, with the announcement of the Senior Canada-150 Research Chair in Climate Forcing of Sea Ice (Dr. Julienne Stroeve) and the potential new Canada Excellence Research Chair in Arctic Ice, Freshwater-Marine Coupling and Climate Change. The objective of this retreat was to review the objectives of CEOS and develop a vision and mission statement for the Centre that would encompass the focus of the work done at the Centre. The new vision and mission statements are provided in the summary to this document. In addition, challenges and priorities for the next year were outlined, providing direction for the management of the Centre.
6.0 Future Growth of the Centre

Over the next seven years, it is expected that CEOS will grow significantly, both in terms of research focus, as well as logistically. With the successful appointment of a new Senior Canada-150 Research Chair in Climate Forcing of Sea Ice (Dr. Julienne Stroeve) and the anticipated announcement of the new Canada Excellence Research Chair in Arctic Ice, Freshwater-Marine Coupling and Climate Change, CEOS and the University of Manitoba will be the only institution nationally to be awarded both research chairs in the physical sciences. These appointments will expand our research interests in Arctic system sciences, focusing on the coupling of freshwater glacial and sea ice marine systems. This coupling will allow researchers to develop a more complete understanding of the Arctic system in the face of climate change. In addition, a major part of these programs will be the integration of western science with Inuit/Indigenous knowledge through input from Inuit knowledge holders, community-based monitoring programs and in situ field studies. As part of this focus, the Pikialasorsuaq partnership will be developed in the North Water Polynya region of Baffin Bay. This is a collaboration between CEOS/University of Manitoba, Oceans North, the Inuit Circumpolar Conference (ICC), Fisheries and Oceans Canada and Greenland Institute of Natural Resources.

It is also anticipated that the Churchill Marine Observatory (CMO) will be constructed by December 2019 and following a period of setup and testing, research will commence in early to mid-2020. The opening of this facility will increase the profile of CEOS as an international research centre, attracting researchers from around the world. CMO will also require additional staff to oversee the logistics associated with the research.

The anticipated success in these research chairs, as well as success in other research programs over the past year, will result in a significant growth at the Centre in terms of personnel and laboratory capabilities. It is expected that over the next year, the Centre will have approximately 40 new staff, including 5 new faculty members. In addition, the number of graduate students affiliated with CEOS will grow as well, contributing to the research output of the Centre. The renovation of the organics extraction lab as part of the Multiple Partners Research Initiative (MPRI) DFO grant awarded to Drs. Feiyue Wang, Gary Stern, Soren Rysgaard and Zou Zou Kuzyk, will increase our capabilities in PETRL and UCTEL to support the following analytical chemistry activities: management and coordination of chemical analysis activities throughout the MPRI, including coordination of sampling, sampling preservation and extraction, QA/QC and data reporting; methodological development and validation, analyzes and reporting of chemical composition of oil and oil products, hydrocarbons targeted/nontargeted compounds and naturally degraded products and elemental composition; assistance in analytical data for all MPRI researchers (network); analytical capacity building in other national MPRI laboratories; training of HQP in analytical techniques and research expertise.
7.0 Difficulties

One of the main accomplishments of CEOS over the past year has been the significant growth in research chairs and grants. However this rapid growth has resulted in a number of difficulties that have/will pose significant limitations for the Centre over the next year. One of the major difficulties is space. With an anticipated growth of approximately 40 new faculty/staff in the next year, office and laboratory space is limited and it will be difficult to provide this space within the current allocation (primarily on the 4th and 5th floors of Wallace Building). With the anticipated purchasing of additional equipment by the new faculty members, the space to house this equipment, as well as the required infrastructure will be a significant limitation. Administrative support and monies to run such a large research centre is also a difficulty. Some of the technical/administrative support staff members are paid through grants awarded to individual principal investigators. These positions, while vital to the operation and the research conducted at the Centre, are on a year-to-year basis and thus creating insecurity in job retention, as well as limiting the candidates for new positions. One of the hallmarks of CEOS over the past decade has been the community outreach programs lead by faculty and staff at the Centre. These include Arctic Science Days at Fort Whyte Alive and Lets Talk Science. In the past, these important outreach programs were lead by a support staff member at the Centre, however due to funding issues, this position was not continued into 2018/19. Currently the organization of these programs is lead by the Executive Director of the Centre.