Executive Summary

This report covers the period April 1, 2016 to March 31, 2017. CEOS is a water-centric research centre with a particular interest in how climate forces variability and change in the hydrosphere.

CEOS researchers are drawn from academic units within the Clayton H. Riddell Faculty of Environment, Earth and Resources, the Faculties of Engineering, Arts, Agriculture, and the Asper School of Business. We collaborate with numerous other researchers within the University of Manitoba, and at universities and government laboratories both nationally and internationally.

CEOS hosts the University of Manitoba’s CERC program in Geomicrobiology and Tier-1 CRC programs in Arctic System Science and Arctic Environmental Chemistry. Major collaborative national and international research partnerships and initiatives are associated with these programs. Researchers participate in national and international research networks, including: Networks of Centres of Excellence (NCE) ArcticNet and MEOPAR, the Arctic Science Partnership (ASP), the NSERC CRD network BaySys, Genomics Canada - GENICE, Churchill Marine Observatory (CMO).

In the reporting year, we mentored seven undergraduate students, 34 master’s students and 27 doctoral students, along with 24 post-doctoral fellows/research associates. Eight graduate students completed their studies during the reporting period.

CEOS remains a very productive research unit. In the reporting period, faculty had published 54 peer-reviewed journal articles in top journals, and secured $7.2 million in research support. This year, it was announced that CEOS researchers have secured funding for the GENICE project ($10.7 million over 4 years).

CEOS researchers are active in community outreach, annually providing public lectures, radio, television, newspaper, and web-based stories in the fields of climate change, weather, drought assessment, flooding, water quality, including eutrophication in Manitoba lakes. In addition, CEOS works closely with northern and stakeholder communities with the objective of making the science that we conduct relevant to those with a stake in understanding variability and change. The Centre also operates the highly successful Schools on Board program, which brings high school students and teachers to the Arctic aboard the CCGS Amundsen icebreaker for immersion into the field of polar marine science.

CEOS researchers have been profiled on numerous national and international broadcasts and documentaries on climate change. The Centre has an international reputation as a “Centre of Excellence” in Arctic marine systems and climate change. It is widely known to have played a key role in detecting changes in sea ice dynamic and thermodynamic processes driven by these physical changes.
As a Centre, we continue to realize our five-year goals. These are:

• As one of three founding members of the Arctic Science Partnership – to grow the partnership in the areas of Arctic research and education, with the addition of new associate members, including the University of Tromsø in Norway, the Alfred Wegner Institute in Germany, Lund University in Sweden, and the University of Southern Denmark.

• Develop research programs associated with new CRC Tier-1 (Dr. Feiyue Wang) in Arctic Environmental Chemistry.

• Continue to develop the Churchill Marine Observatory (CMO) and associated Environmental Observing System, Oil in Sea Ice Mesocosms, the coastal vessel – the White Diamond, labs at UM, and to fill NSERC IRC positions associated with the infrastructure program.

• Continued strengthening of partnerships developed through the ArcticNet Network of Centres of Excellence, and research icebreaker Amundsen-based programs.

• Play a central role in the development of a pan-Canadian network to replace ArcticNet.

• Continued operation of the Sea-ice Environmental Research Facility (SERF) for research into sea ice.

• Forward BaySys research, including Bay-wide cruise of the Amundsen.

• Compete for CERC in the area of ocean-sea ice coupling.

• Compete for Canada 150 Research Chair in the area of atmosphere-sea ice coupling.

• Develop white paper for a major infrastructure program known as the Baffin Bay Observing System (BBOS)

• Develop a major proposal to NSERC (Strategic Network) OSICA – Oil Spills in Ice-Covered Arctic Waters.

• Continue developing major outreach and education program: “Expedition Churchill – A Gateway to Arctic Research”.
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1 Mission

The Centre for Earth Observation Science (CEOS) will seek a deeper understanding of the physical, chemical and biological interactions of Earth spheres that determine the past, current and future states of the oceans and atmosphere and connecting hydrology with other environmental systems. These endeavors will contribute to the economic, cultural, and physical well-being of the people of Manitoba, Canada and the world.

CEOS was established as a Type I Research Centre within the Department of Geography in the Faculty of Arts in 1994. In 2002, the Centre became part of the Clayton H. Riddell Faculty of Environment, Earth and Resources as a stand-alone unit along with the Departments of Environment & Geography, Geological Sciences and the Natural Resources Institute. In 2005, the Centre was relocated to the Wallace Building on the Fort Garry Campus. CEOS has been able to establish a strong national and international research reputation. In doing so, the Centre has formed broad partnerships with research groups and industry nationally and internationally, and leveraged significant funding. This support has not only enhanced the research capacity of the Centre, but it has also enabled the University to attract and retain new faculty and graduate students. Through these partnerships CEOS has been key to the development of national research networks, including NSERC research networks North Water Polynya Study (NOW); Canadian Arctic Shelf Exchange Study (CASES); the NCE ArcticNet; International Polar Year Circumpolar Flaw Lead Study (CFL), the Arctic Science Partnership, Genome Canada GENICE, among others. The Centre is also a founding member and an active participant in the Lake Winnipeg Research Consortium (LWRC). These partnerships have provided funded research opportunities for faculty, Master’s and Ph.D. students.

The unit’s main objective has been to understand and quantify climate forced variability and change in the hydrosphere and how climate change affects (i) the cryosphere, (ii) water related processes operating within the Earth System, and (iii) feedback between the atmosphere, temperature and climate change. The Centre is recognized internationally as one of the most influential Arctic System Science research units in the world, and CEOS fits centrally into the UM’s “Established Signature Area of Research” - Arctic System Science and Technology, as outlined in the University’s 2015 Strategic Research Plan.

As a Centre, our goals are:

- to maintain our standing as one of the strongest and most influential Arctic System Science research units in the world;
- to build on expertise, and foster growth and research capacity in other strategic areas, including aquatic systems, environmental chemistry and toxicology of contaminants in the environment, and severe weather;
- continue to provide an outstanding HQP training environment;
- provide a service to the peoples of Manitoba, Canada and the global community by undertaking science in areas deemed by society as important;
• Engage broadly with stakeholders in terms of the ongoing impacts of climate change.

Areas of existing research activity are divided among six key themes:

• **Ocean, sea ice and climate**, including the study of geophysical, biogeochemical and biological processes and properties of sea ice and the ocean; their linkages and feedbacks across the ocean, ice and atmosphere at cascading temporal and spatial scales.

• **Contaminants** such as mercury in the Arctic food web. We study the pathways that contaminants follow in the ecosystem, and how they might be affected by climate change.

• **Mammals**, how they interact with different ice types, and how they could be affected by the changing environment.

• **Meteorology**, improving our understanding of the planetary boundary layer, with a focus on atmospheric phenomena such as precipitation and cloud formations to better predict storms and extreme weather.

• **Aquatic Systems**, freshwater availability, water quality and ecology within watersheds and lakes over a geographic domain that extends from the prairies to Canada’s Arctic.

• **Traditional and local knowledge** from Northern people contributes to our understanding of the environment.

The Centre is supported by the University of Manitoba through an operating grant and transfer of research-leveraged funds through the Clayton H. Riddell Faculty of Environment, Earth, and Resources. Researchers operating under the CEOS umbrella procured ~$7.2 million in research funds in the reporting year. NSERC, the NCE, CRC, and CERC are major funding sources. Research funds cover an additional 19 support staff, five nil-salaried professors, 16 research associates, and eight post-doctoral fellows. Our graduate student cohort was 61 (combined master’s and doctoral) during the reporting year. Operational support from baseline assists with a range of services, including phones, office consumables, printing/copying, physical plant renovations, etc. This year, as in previous years, baseline operational support is supplemented by research funds.
2 CEOS Membership

Membership includes academic staff from UM (ranks ranging from Assistant to Full Professor), grant funded research professors at the UM, researchers from other universities and government departments who are adjunct to departments at UM; research associates (RAs), post-doctoral (PDF) and graduate students. The appointments of our grant-funded professors are to departments within CHRFEER, as are appointments of research associates. Grant-funded professors are adjunct to the host department of the academic staff. PDFs and graduate students have their academic appointments to departments at UM and supervised by CEOS members, including academic staff, research professors and adjunct professors.

2.1 Faculty (Academic Staff, * indicates their budgets are administered by CEOS staff)

1. Genevieve Ali, Assistant Professor, Department of Geological Sciences
2. David Barber*, Professor, Department of Environment & Geography
3. Jens Ehn*, Associate Professor, Department of Environment & Geography
4. Norman Halden, Professor, Department of Geological Sciences
5. John Hanesiak*, Professor, Department of Environment & Geography
6. Mark Hanson, Associate Professor, Department of Environment & Geography
7. John Iacozza, Instructor, Department of Environment & Geography
8. Dustin Isleifson, Assistant Professor, Department of Electrical and Computer Engineering,
9. Zou Zou Kuzyk*, Assistant Professor, Department of Geological Sciences
10. David Lobb, Professor, Department of Soil Science
11. Brooke Milne, Associate Professor, Department of Anthropology
12. Puyan Mojabi, Associate Professor, Department of Electrical and Computer Engineering
13. Christopher-John Mundy*, Associate Professor, Department of Environment & Geography
14. Jill Oakes, Professor, Department of Environment & Geography
15. Tim Papakyriakou*, Professor, Department of Environment & Geography
16. Ron Stewart*, Professor, Department of Environment and Geography
17. Tricia Stadnyk, Associate Professor, Department of Civil Engineering
18. Søren Rysgaard*, Professor, Department of Geological Sciences
19. Feiyue Wang*, Professor, Department of Environment & Geography

2.1.1 Grant Funded Research Professors (nil-salary appointments)

1. Igor Dmitrenko*, Research Scientist, Department of Environment & Geography
2. Ryan Galley*, Research Scientist, Department of Geological Sciences
3. Masayo Ogi, Research Scientist, Department of Environment & Geography
4. Monika Pučko*, Research Scientist, Department of Environment & Geography
5. Gary Stern*, Research Scientist, Department of Environment & Geography
2.2 Research Associates
1. David Babb
2. Lucette Barber
3. Alexis Burt
4. Lauren Candlish
5. Ashley Gaden
6. Nicolas-Xavier Geilfus
7. Joel Heath
8. Michelle Kamula
9. Sergei Kirillov
10. Marcos Lemes
11. Zhou (George) Liu
12. Jennifer Lukovich
13. Greg McCullough
14. Nathalie Thériault
15. Emmelia Wiley
16. Cornelia Willing

2.3 Support Staff
1. Debbie Armstrong - UCTEL Technician
2. David Binne – SERF Technician
3. Wayne Chan – Research Computer Analyst
4. Michelle Clyde – Schools on Board Coordinator
5. Linda Chow – Office Assistant
6. Jennifer Hollar – Office Assistant
7. Claire Hornby – BaySys Coordinator
8. Ashley Elliott – Technician
9. Justine Hudson – Student Technician
10. Shiva Laskari – Technician
11. Sebastian Luque – Technician
12. Claire Reis – Lake Winnipeg Basin Portal Coordinator
13. Jake Ritchie – Technician
14. Aggie Roberecki – Administrative Assistant
15. Cris Seaton – Technician
16. Eva Slacek – Technician
17. Ashley Soloway – Technician
18. Heather Stark – Churchill Marine Observatory (CMO) Coordinator
19. Denise Whynot – Office Assistant (part time)
## 2.4 Graduate Students
CEOS had 27 doctoral and 34 master’s students during the reporting period.

### 2.4.1 Doctoral

<table>
<thead>
<tr>
<th>Name</th>
<th>Department</th>
<th>Advisor(s)</th>
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<tbody>
<tr>
<td>Samuel Bansah</td>
<td>Geological Sciences</td>
<td>Ali</td>
</tr>
<tr>
<td>Atreya Basu</td>
<td>Environment &amp; Geography</td>
<td>Ehn</td>
</tr>
<tr>
<td>Daniel Betancourt</td>
<td>Environment &amp; Geography</td>
<td>Stewart</td>
</tr>
<tr>
<td>Wieter Boone</td>
<td>Geological Sciences</td>
<td>Rysgaard/Dmitrenko</td>
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<tr>
<td>Tonya Burgers</td>
<td>Environment &amp; Geography</td>
<td>Papakyriakou</td>
</tr>
<tr>
<td>Karley Campbell</td>
<td>Environment &amp; Geography</td>
<td>Mundy/Rysgaard</td>
</tr>
<tr>
<td>Jon Challis</td>
<td>Chemistry</td>
<td>Hanson</td>
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<tr>
<td>Luis Gerardo Chaves</td>
<td>Environment &amp; Geography</td>
<td>Hanson</td>
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<td>Odile Crabeck</td>
<td>Geological Sciences</td>
<td>Rysgaard/Galley</td>
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<tr>
<td>Oonagh Daly</td>
<td>Environment &amp; Geography</td>
<td>Hanson</td>
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<tr>
<td>(withdrawn)</td>
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<tr>
<td>Cassandra Debets</td>
<td>Biological Sciences</td>
<td>Ferguson</td>
</tr>
<tr>
<td>Aurelie Delaforge</td>
<td>Environment &amp; Geography</td>
<td>Mundy</td>
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<tr>
<td>Reza Gholami</td>
<td>Electrical &amp; Computer Engineering</td>
<td>Barber/Okhmatovski</td>
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<td>Bob Gill</td>
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<td>Papakyriakou</td>
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<tr>
<td>Mary Grace Golfo-Barcelona</td>
<td>Anthropology</td>
<td>Milne</td>
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<td>Md Aminul Haque</td>
<td>Geological Sciences</td>
<td>Ali</td>
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<tr>
<td>Shabnam Jafarikhasrah</td>
<td>Environment &amp; Geography</td>
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<td>Satwant Kaur</td>
<td>Environment &amp; Geography</td>
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<tr>
<td>David Landry</td>
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<tr>
<td>Lisa Matthes</td>
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<td>Maliheh Rabie</td>
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<td>Cody Ross</td>
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<td>Kang Wang</td>
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<td>Kristin Westdal</td>
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<td>Barber/Ferguson</td>
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<tr>
<td>Kedong Zhang</td>
<td>Environment &amp; Geography</td>
<td>Wang</td>
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### 2.4.2 M.Sc.

<table>
<thead>
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<tr>
<td>Juris Almonte</td>
<td>Environment &amp; Geography</td>
<td>Stewart</td>
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<tr>
<td>Wilhelmina Armah</td>
<td>Geological Sciences</td>
<td>Kuzyk</td>
</tr>
<tr>
<td>Neal Bailey</td>
<td>Environment &amp; Geography</td>
<td>Wang</td>
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<tr>
<td>Oksana Banias-Schimnowski</td>
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<td>Jennifer Bruneau</td>
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<td>Hanesiak</td>
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<tr>
<td>Yanique Campbell</td>
<td>Environment &amp; Geography</td>
<td>Barber/Ehn</td>
</tr>
<tr>
<td>Laura Dalman</td>
<td>Environment &amp; Geography</td>
<td>Mundy/Barber</td>
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<tr>
<td>Durell Desmond</td>
<td>Environment &amp; Geography</td>
<td>Stern/Barber</td>
</tr>
<tr>
<td>Aura Diaz</td>
<td>Environment &amp; Geography</td>
<td>Ehn/Papakyriakou</td>
</tr>
<tr>
<td>Annie Eastwood</td>
<td>Environment &amp; Geography</td>
<td>Kuzyk</td>
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<tr>
<td>Mairi Fenton (withdrawn)</td>
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<td>Maha Ghazal</td>
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<td>Claire Herbert</td>
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<td>Samantha Huyghe</td>
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<tr>
<td>Holly Kajpust</td>
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<td>Skye Kushner</td>
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<td>Kathleen MacMillan</td>
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<td>Nicole Pogorzelec</td>
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<td>Scott Pokorny</td>
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<td>Tassia Stainton</td>
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<td>Adam Vanderpont</td>
<td>Environment &amp; Geography</td>
<td>Hanson</td>
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<tr>
<td>Kyle Ziolkowski</td>
<td>Environment &amp; Geography</td>
<td>Hanesiak</td>
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### 2.4.3 M.A.

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<tr>
<th>Name</th>
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<tr>
<td>Elenore Hood</td>
<td>Anthropology</td>
<td>Milne</td>
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<tr>
<td>Elizabeth Worden</td>
<td>Environment &amp; Geography</td>
<td>Oakes/Loseto</td>
</tr>
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</table>
2.5 Graduates
Eight CEOS students graduated during the 2016-17 reporting period. Five master’s students and three doctoral students completed their studies.

Jasmine Brewster (M.Sc.)(May 2016), Environment & Geography, Advisors: Stern/Loseto
Thesis title: Characterizing the diet and habitat niches of coastal fish populations in the Beaufort Sea Tarium Nirutuat Marine Protected Area.

Nariman Firoozy (Ph.D.)(October 2016), Electrical & Computer Engineering, Advisors: Barber/Mojabi
Dissertation title: Radar cross section data inversion for snow-covered sea ice remote sensing.

Ida Hung (M.Sc.)(February 2017), Environment & Geography, Advisor: Stewart
Thesis title: Characteristics and Formation of Precipitation over the Kananaskis Emergency Site during March and April 2015.

Jack Landy (Ph.D.)(May 2016), Environment & Geography, Advisor: Barber

Jing Ma (Ph.D.)(October 2016), Environment & Geography, Advisors: Hanson & Hipel
Dissertation title: Influencing factors on public participation in solid waste source-separated collection in Guilin, China.

Cody Ross (M.Sc.)(November 2016), Geological Sciences, Advisor: Ali
Thesis title: Assessment of soil water movement and the relative importance of shallow subsurface flow in a near-level Prairie watershed.

Heather Stark (M.Sc.)(May 2016), Environment & Geography, Advisor: Barber
Thesis title: On the spatial and temporal variability of ice arches associated with the formation of the North Water (NOW) Polynya.

Rui Zhang (M.Sc.) (October 2016), Electrical & Computer Engineering, Advisor: Papakyriakou

2.6 Post-doctoral Fellows
1. David Capelle – Supervisor: Papakyriakou
2. Diana Chirkova – Supervisor: Stern
3. Virginie Galindo – Supervisor: Rysgaard
4. Carie Hoover – Supervisor: Loseto
5. Yubin Hu – Supervisors: Wang/Rysgaard/Barber
6. Jack Landy – Supervisor: Barber
8. Thomas Richerol – Supervisors: Barber/Rysgaard
2.7 Adjuncts (to University Departments)
1. S. Belanger, Professor, Département de biologie, chimie et géographie, Université Québec Rimouski
2. I. Dmitrenko, Research Scientist, grant-funded, Environment and Geography, University of Manitoba
3. Brent Else, Assistant Professor, Department of Geography, University of Calgary
4. Steve Ferguson*, Research Scientist, Fisheries and Oceans Canada
5. Ryan Galley, Research Scientist, grant-funded, Department of Geology, University of Manitoba
6. Casey Hubert, Associate Professor, Department of Biological Sciences, University of Calgary
7. Lisa Loseto, Research Scientist, Fisheries and Oceans Canada (Winnipeg, MB)
8. Robie Macdonald, Research Scientist Emeritus, Fisheries and Oceans Canada (Sydney, BC)
9. Greg McCullough, Research Scientist, grant-funded, Department of Geology, University of Manitoba
10. Christine Michel, Research Scientist, Fisheries and Oceans Canada (Winnipeg, MB)
11. Lisa Miller, Research Scientist, Fisheries and Oceans Canada (Sydney, BC)
12. Peter Outridge, Research Scientist, Natural Resources Canada (Ottawa, ON)
13. M. Púcko, Research Scientist, grant-funded, Environment and Geography, University of Manitoba
14. James Reist, Research Scientist, Fisheries and Oceans Canada (Winnipeg, MB)
15. Michael Stainton, Research Scientist, Fisheries and Oceans Canada (Winnipeg, MB)
16. Gary Stern, Research Scientist, grant-funded, Environment and Geography, University of Manitoba
17. Wojciech Walkusz, Research Scientist, Fisheries and Oceans Canada (Winnipeg, MB)

2.8 Summer Students
Seven summer students assisted various faculty members as research assistants or technicians in 2016-17.

<table>
<thead>
<tr>
<th>Name</th>
<th>Department</th>
<th>Supervisor</th>
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<tbody>
<tr>
<td>Alessia Guzzi</td>
<td>Environment &amp; Geography</td>
<td>Barber</td>
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<tr>
<td>Larissa Gospodyn</td>
<td>Environment &amp; Geography</td>
<td>Barber</td>
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<tr>
<td>Manon Soulard</td>
<td>Geological Sciences</td>
<td>Ali</td>
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<tr>
<td>Kelsey Margraf</td>
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<tr>
<td>Adrienne Schmall</td>
<td>Geological Sciences</td>
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<tr>
<td>Natalie Wagner</td>
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<td>Hanson</td>
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<tr>
<td>Hannah Polaczek</td>
<td>Environment &amp; Geography</td>
<td>Hanson</td>
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</table>
3  Education, Outreach & Communications

The Centre for Earth Observation Science is involved in numerous educational outreach activities. Schools on Board, a national outreach program of ArcticNet, is based out of CEOS. Its goal is to provide high school students with authentic and simulated experiences in conducting Arctic science research.

3.1  Schools on Board

Coordinator: Michelle Clyde

3.1.1  Schools on Board – Arctic Field Program

The Centre runs the highly successful Schools on Board program, which brings high school students and teachers to the Arctic aboard the CCGS *Amundsen* icebreaker to provide an immersive experience in the field of polar marine science.

Each year, a team of high school students and teachers are selected from across Canada to participate in an ArcticNet research program on board the CCGS *Amundsen*. Schools are given the unique opportunity to send students and teachers to the Arctic to participate in an educational experience completely integrated into the research activities of the ArcticNet science team.

Participants in the field program joined the 2016 ArcticNet Scientific Expedition in the community of Kugluktuk, NU and participated in the research operations leading up to Pond Inlet, NU.

Schools represented in the 2016 field program include:

- F. H. Collins Secondary School - Whitehorse, YK
- Kiilinik High School - Cambridge Bay, NU
- Nasivvik High School - Pond Inlet, NU
- École Secondaire de Nanaimo - Nanaimo, BC
- Peace River South SD. 59 – Dawson Creek, BC
- Strathclair Community School – Strathclair, MB
- Elmwood High School – Winnipeg, MB
- Kelvin High School – Winnipeg, MB
- Collège Jean-de-Brébeuf - Montréal, QC
- Collège François-de-Laval – Québec, QC
3.1.2 Arctic Science Days

Arctic Science Day focuses on bringing Arctic scientists and high schools students together in an outdoor learning environment. 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
- Arctic people and their environment

**Arctic Science Day at FortWhyte Alive – March 9, 2017**

This annual event is the result of a successful partnership with FortWhyte Alive, a nationally acclaimed outdoor education facility in Winnipeg, and a collaboration with the Freshwater Institute (Fisheries and Oceans Canada). It continues to reach over 150 middle years and senior years students and educators from 10-15 schools every year. Participants come from both city and rural schools. A team of 25-30 CEOS graduate students and scientists created six different stations that included hands-on activities and demonstrations. These stations included: ice cores, water and snow sampling, weather monitoring, marine mammals, and archaeology.
3.1.3 Arctic Climate Change Youth Forum

The Arctic Climate Change Youth Forum (ACCYF) is a youth oriented, day-long conference devoted to raising awareness of climate change and ongoing research in Canada’s Arctic. In addition to science, the day will also include the northern perspective on climate change and the complexities of a changing Arctic. The conference is held in conjunction with a national or international scientific meeting and features keynote speakers and presentations from scientists in the forefront of Arctic research. An ACCYF is co-hosted with a high school and organized by high school students for high school students.

ACCYF 2016

High School – Elmwood High School (Winnipeg)
Science Meeting – 2016 Arctic Science Meeting, Winnipeg, Manitoba
Number of student participants – 100 from 10-15 schools

3.2 Science Rendezvous – May 13, 2016

Science Rendezvous is a national annual festival that takes science out of the lab and to the general public. Science Rendezvous is one of Canada’s largest celebrations of the amazing feats of science and engineering. The Faculty of Science hosted the University of Manitoba’s Science Rendezvous on May 13, 2016 engaging adults and children in a day of free fun and discovery.

Graduate students from the Centre for Earth Observation Science continue to participate in this event and have continued to add new interactive activities to introduce the Arctic and Arctic research to young families in attendance.

3.3 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 ~$800K (Cash ~$220K). CEOS partnered with the University of Manitoba, Town of Churchill, Churchill Northern Studies Centre, VIA Rail Canada, Travel Manitoba, and Assiniboine Park Zoo – Journey to Churchill.

Expedition Churchill 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 this northern system, including sensitivities and implications of climate change; (ii) promote the University of Manitoba collaborations with the Town of Churchill, Journey to Churchill (Winnipeg Assiniboine Park Zoo), Churchill Northern Studies Centre, and Travel Manitoba; (iii) enhance visitor experience in transit to, and within Churchill; (v) promote community engagement in Churchill, and on a broader scale, (iv) engage with public interest in climate change research and inspire a greater sense of stewardship and sustainable development of the North. The unique features of this outreach initiative include using a VIA Rail passenger train; interactive interpretive kiosks at high traffic public locations within Manitoba, and a multi-media interactive e-book to educate and raise awareness.
4 Service

CEOS researchers have been profiled on numerous national and international broadcasts and documentaries on climate change. The Centre has an international reputation as a “Centre of Excellence” in Arctic marine systems and climate change, and is widely known to have played a key role in detecting changes in sea ice dynamic and thermodynamic processes driven by global scale climate change and in the determination of changes in the marine ecosystem driven by these physical changes.

CEOS researchers are active in the community, annually providing public lectures, radio, television, newspaper, and web-based stories in the fields of climate change, weather, drought assessment, flooding, water quality, and freshwater eutrophication. In addition, CEOS works closely with northern and stakeholder communities with the objective of making the science that we conduct relevant to those with a stake in understanding variability and change.

4.1 Honours/Awards

• April 7, 2016: Dr. David Barber was a recipient of the Dr. John M. Bowman Memorial Winnipeg Rh Institute Award.
• December 30, 2016: Dr. David Barber was appointed as an Officer of the Order of Canada by Governor General David Johnston, “for his leadership in environmental science and for his contributions to the study of arctic sea ice processes”.

4.2 Workshops

4.2.1 Oil Spills in Ice-Covered Arctic (OSICA) workshop - March 13–14, 2017
Co-organizers: Fei Wang (CEOS) and Carl Brown (Environment and Climate Change Canada).

A total of 66 participants from academic, government, industry, and Indigenous/Northern organizations attended the workshop, with an aim towards building a national consortium on oil spills in ice-covered Arctic waters. The workshop resulted in the formation of the Canadian OSICA Consortium, and explored new opportunities for coordinating funding and logistics in oil spill research, technological development, and policy-making with respect to potential oil spills in the Arctic.

4.3 Media

The following is a selection of media interviews and articles that occurred during the reporting period.

• Edmonton Journal, Phone interview with Dr. John Hanesiak about tornado warnings/research, July 13, 2016.
• Canadian Geographic, article by Michela Rosano, “Team of scientists to freeze research vessel in Arctic ice”, April 14, 2016.
• *CBC News*, “Arctic researcher, comedian among 6 Winnipeggers honoured with Order of Canada appointments”. Article about Dr. David Barber receiving Order of Canada, December 30, 2016.

• *CBC News*, “Scientists gathering in Winnipeg to focus on 'complex' changing Arctic climate”, December 3, 2016. Article about ArcticNet conference in Winnipeg.

• *CBC News*, “Ice quake shakes things up at Madge Lake, Sask.”, December 30, 2016. Interview with Dr. David Barber regarding ice quake in Saskatchewan.

• *Winnipeg Free Press*, “Manitobans appointed to the Order of Canada”, December 30, 2016. Article about Dr. David Barber receiving Order of Canada.

• *Winnipeg Sun*, “Winnipeggers named to Order of Canada”, December 30, 2016. Article about Dr. David Barber receiving Order of Canada.


• *Nature*, “Speedier Arctic data as warm winter shrinks sea ice”, 531(7592), 01 March 2016. Article by Alexandra Witze, quoting Dr. David Barber on importance of sea ice thickness measurements.

• *National Post*, “With a key Arctic research project set to close in 2018, Trudeau's science minister considers next steps”, January 8, 2017. Article by David Akin. Dr. David Barber is interviewed about the future of ArcticNet.


• *UM Today*, “What changing Arctic sea-ice tells us about climate change”, June 7, 2016. Dr. David Barber discusses Arctic climate change.

• *UM Today*, “Seven surprising results from shrinking sea ice and other research”, April 7, 2016. Article about Dr. David Barber receiving Dr. John M. Bowman Memorial Winnipeg Rh Institute Foundation Award.

• *Sou’wester*, Danielle Da Silva, “Grants fund water research”, March 31, 2017. Article about Claire Herbert receiving funding for freshwater research.

• *UM Today*, “Professor Søren Rysgaard guides US Secretary of State, John Kerry, to witness Climate Change in Greenland”, June 28, 2016. Article about Dr. Søren Rysgaard meeting Secretary of State John Kerry.
• *Globe and Mail*, Ivan Semeniuk, “Arctic researchers propose plan to monitor Baffin Bay”, February 12, 2016. Article about BBOS project.

• *UM Today*, “Vote: SIKU mapping platform a finalist for Google challenge”, March 22, 2107. Article about Joel Heath and SIKU project.


• *UM Today*, “Professor leads the way in Arctic environmental chemistry”, December 15, 2106. Article about Dr. Fei Wang and SERF facility.

• *UM Today*, “Manitoba and Genome Canada invest in research in Canada’s Arctic”, January 16, 2017. Interview with Dr. Gary Stern about GENICE project.


• Trent University Daily News, “A Solution to Pollution: Expert in Arctic Environmental Chemistry Delivers 2016 Stairs Lecture”. Article about Dr. Fei Wang delivering Stairs Lecture at Trent University.

• Ducks Unlimited Canada, Prairie Pothole Region, “Made to Measure DUC teams up with Manitoba Hydro and the University of Manitoba to assess the best way to measure greenhouse gas fluxes in aquatic ecosystems”, featuring Dr. T. Papakyriakou’s collaborative greenhouse gas project. October 21, 2016. [http://www.ducks.ca/stories/prairie-pothole-region/made-to-measure/](http://www.ducks.ca/stories/prairie-pothole-region/made-to-measure/)

5 Activities and Research Projects
Selected ongoing major projects are highlighted here. A full list of CEOS projects can be found at: [http://umanitoba.ca/faculties/environment/departments/ceos/research/projects.html](http://umanitoba.ca/faculties/environment/departments/ceos/research/projects.html).

5.1 Churchill Marine Observatory (CMO)
The Churchill Marine Observatory (CMO) will be a globally unique, highly innovative, multidisciplinary research facility located in Churchill, Manitoba, adjacent to Canada’s only Arctic deep-water port. The CMO will directly address technological, scientific, and economic issues pertaining to Arctic marine transportation and oil and gas exploration and development throughout the Arctic.

CMO will position Canada as a global leader of research into the detection, impacts, and mitigation of oil spills in sea ice and the effect of climate change and water regulation on freshwater-marine coupling in the Arctic. Knowledge gained through CMO will strengthen Canada’s technological capacity to protect the Arctic environment. Partnership s with indigenous organizations will ensure knowledge exchange; the private sector will provide market-driven uptake of technology; and various levels of government will transfer knowledge into policy and regulation.

CMO will include an Oil-in-Sea-Ice-Mesocosm (OSIM), an Environmental Observing (EO) system, and a logistics base. OSIM will consist of two saltwater sub-pools designed to simultaneously accommodate contaminated and control experiments on various scenarios of oil spills in sea ice. The EO system will be located in the Churchill estuary and along the main shipping channel across Hudson Bay and Strait, with labs both in Churchill and at the UM. The EO system will provide a state-of-the-art monitoring system and will be used to scale process studies conducted in OSIM to Hudson Bay and the larger Arctic environment. The logistics base will underpin all CMO research. Construction of the OSIM facility has
been impacted by the disruption to rail service associated with damage to the rail line that occurred during the spring of 2017. Procurement of equipment has been on-going. Labs at the UM are near completion. The refit to the CMO-EO coastal vessel, *White Diamond*, associated with the facility is now completed and the vessel is ready for operation. The vessel is overwintering in Summerside, Prince Edward Island.

![CMO research vessel, White Diamond](image)

Additional information on CMO is available at: [http://umanitoba.ca/ceos/research/CMO.html](http://umanitoba.ca/ceos/research/CMO.html).

### 5.1.1 Anticipated Outcomes

CMO is specifically designed to investigate a variety of contaminants under both landfast first-year sea ice and mobile ice types. Anticipated outcomes for CMO include:

- A newly developed suite of remote sensing and modelling tools for detecting contaminants across a range of space and time scales.
- Procedures to mitigate environmental impacts from a spill using conventional techniques such as dispersants and in situ burning, in addition to novel techniques such as cold temperature-adapted bioremediation.
- Advanced capacity to monitor for and quantify potential impacts from shipping and development activities in the Arctic while also providing advanced information required by operators for safe shipping, exploration and development.
The true strength of the proposed program is the full integration of OSIM research and technology development with the state-of-the-art EO system. The EO system directly supports OSIM by supplying in situ data on the natural range and variability of the key environmental factors that define ocean/sea ice/atmosphere (OSA) climate states (e.g., ocean salinity, temperature, ice thickness, roughness, and biological productivity). By deploying identical instruments in both OSIM and the EO system, equivalent observations will be made in the upper ocean, ocean-ice interface, through the ice volume, and the ice-atmosphere interface. This level of coordinated cross-disciplinary environmental monitoring is unprecedented in Canada’s Arctic. OSIM will address research of how crude oils, distillates, fuel oils, herding agents, dispersants and residues from in situ burning, liquefied natural gas, and other transportation-related contaminants affect processes across the OSA interface.

5.2 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 overarching goal of the program is to understand the role of freshwater in Hudson Bay marine and coastal systems. In particular, the network will seek a scientific basis to distinguish climate change effects from those of hydroelectric regulation of freshwater on physical, biological, and biogeochemical conditions in Hudson Bay. Researchers will use a combination of data mining, new data collection, and process modeling to achieve these goals.

During the 2016-2017 fiscal year the following was accomplished:

- **Fall 2016** - The 2016 Fall campaign was focused on deploying moorings in Churchill and Nelson River Estuary, and the James Bay region, using the CCGS Des Grosheilliers. Five oceanographic moorings were deployed from September 26-October 1, 2016. The mooring components were programmed for a one year deployment to be recovered in 2017. Opportunistic water and sediment sampling were executed at each possible station. The full report is available here: http://www.asp-net.org/content/baysys-hudson-bay-system-study-fall-campaign-ccgs-des-groseilliers-0.

- **Winter 2017** - The 2017 winter estuary and mobile ice sampling program was designed to simultaneously characterize physical, biological and biogeochemical conditions in Hudson Bay sub-Arctic estuaries during peak winter sea ice cover. In addition, characterizing the Nelson River plume, and its interaction with the landfast, sea ice and seawater, as it flows under and along the landfast ice cover. The focus of the winter field campaign was to perform basic sampling for nutrients and biology (ice algae) from the Nelson Estuary. In addition, the team installed ice-tethered moorings. Further details and the reports for the Nanuuk and Churchill campaigns are available here: http://www.asp-net.org/content/baysys-hudson-bay-system-study-winter-campaign.
• **Spring 2017** - Unfortunately, due to unprecedented ice conditions, the CCGS *Amundsen* was redirected to ice-breaking duties and Search and Rescue operations, and the BaySys Summer expedition was cancelled and re-scheduled for 2018. Further details can be found here: [http://www.asp-net.org/content/2017-summer-amundsen-campaign-baysys-cancelled](http://www.asp-net.org/content/2017-summer-amundsen-campaign-baysys-cancelled).

Modeling teams have also accomplished the following:

• Preparation of climate scenarios
• Setup of HYPE model for Hudson Bay drainage basin
• Preparation of standardized meteorological forcing for multi-model uncertainty assessment
• Regulated system models developed
• Assessment of freshwater dynamics in Hudson Bay Complex completed using initial NEMO simulations
• Evaluation of NEMO simulations using existing and most recent winter field campaign observations

5.3 **ArcticNet: a Network of Centres of Excellence**

![Photo of the CCGS Amundsen](Image)

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: Brian Horton.
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).

5.3.1 Integrated Regional Impact Study of the Western and Central Canadian Arctic (IRIS 1)

IRIS 1 – The ArcticNet Integrated Regional Impact Study (IRIS) of the Western and Central Canadian Arctic (aka 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 to publish and print, respectively, >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.

5.3.2 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
Jonathan Andrews – Research Assistant

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.

5.3.2.1 ArcticNet Steering Committee Meeting – Winnipeg, December 5-9, 2016
The third in-person steering committee meeting took place on the Monday before the Annual Scientific Meeting (ASM). During this meeting we gave an overview of the chapter outlines and discussed various issues and suggestions about ways to improve the regional representation of participation on the steering committee. Other ideas of ways to improve the ongoing IRIS development and review processes were discussed. Further to the steering committee meeting, a poster for IRIS-3 was presented at ASM2016 to inform the broader scientific and Arctic community of the IRIS document. There was also a full day oral session, committed to Hudson Bay Research. This session was chaired by David Barber, Zou Zou Kuzyk, and Lauren Candlish.

We expect to have a final version of the Hudson Bay IRIS to be ready for a community launch in March 2018.

5.3.3 2016 ArcticNet Annual Scientific Meeting – Winnipeg, December 5-9, 2016
ArcticNet hosted its 12th Annual Scientific Meeting (ASM) from 5 to 9 December 2016 at the RBC Centre in Winnipeg, Manitoba. The ASM2016 welcomed researchers, students, Inuit, Northerners, policy makers and stakeholders to address the numerous environmental, social, economic and political challenges and opportunities that are emerging from climate change and modernization in the Arctic. As the largest annual Arctic research gathering held in Canada, ArcticNet’s ASM is the ideal venue to showcase results from all fields of Arctic research, stimulate discussion and foster collaborations among those with a vested interest in the Arctic and its peoples. CEOS played an integral role with logistics and side events including an evening at the Winnipeg Art Gallery, a reception at the Assiniboine Park Zoo –
Journey to Churchill, and the Arctic Inspiration Prize Award Ceremony at the Winnipeg Centennial Concert Hall that featured the multi-media Arctic Symphony by composer Vincent Ho, the Winnipeg Symphony Orchestra, and Nunavut Sivuniksavut students. At the meeting, CEOS led a GENICE (Genome Canada) workshop and forum, a Hudson Bay special session, two Integrated Regional Impact Study meetings (IRIS 1 and IRIS 3), and a Baffin Bay Observing System (BBOS) workshop. The 2016 ASM reached a record attendance with approximately 875 attendees.

5.4 GENICE
One of the approaches to mitigating oil spills in marine waters is through bioremediation, whereby naturally present microorganisms biodegrade oils and reduce the negative impacts of the spill. While this phenomenon has been observed in more southerly latitudes, the extent and success of using bioremediation to treat oil in the Arctic marine setting is fairly new and requires further study. Genomics is the study of organism DNA and genetic mapping. By using genomics to study the groups of microorganisms that biodegrade oil, and investigating their associated active genes under various Arctic conditions, we can build capacity for developing cross-cutting spill mitigation strategies and preparation measures among local, regional, national and international levels of governance.
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.

GENICE is structured into six central activities with leaders and teams that will work collaboratively to deliver the above outcomes.

- Activity 1 – Project Management - led by Drs. Casey Hubert (University of Calgary) and Gary Stern (CEOS)
- Activity 2 – Environmental Sampling and Experimental Design - led by Drs. Gary Stern and David Barber (CEOS)
- Activity 3 – Genomics and Bioinformatics - led by Drs. Marc Strous and Casey Hubert (University of Calgary)
- Activity 4 – Sea Ice Environments - led by Drs. David Barber (CEOS) and Charles Greer (McGill University)
- Activity 5 – Benthic Environments - led by Drs. Casey Hubert and Stephen Larter (University of Calgary)
- Activity 6 – Environmental, Ethical, Economic, Legal and Social Aspects (GE3LS) - led by Maribeth Murray (University of Calgary) and John Sinclair (University of Manitoba)

Project outcomes will lead to informed and appropriately scaled plans for coastal and ocean management, spill mitigation strategies, improved risk management, and decreased environmental, social, economic and regulatory uncertainties associated with potential spills. Through the GE3LS component of the project, GENICE will bring together scientists, residents of northern communities, indigenous organizations, government departments, regulatory agencies, non-governmental and private sector groups to contribute their needs and knowledge to the project and also to enact GENICE deliverables.

An announcement was made in December 2016 about the successful funding for GENICE from Genome Canada. Co-lead Gary Stern and coordinator Ashley Gaden participated in a GENICE Knowledge Exchange Forum at the ArcticNet Annual Scientific Meeting, Winnipeg, December 5-9, to consult end-users (stakeholders) in the North and from various organizations (e.g., INAC, DFO) about the GENICE
project. Dr. Stern hired post-doc Dr. Diana Chirkova, who worked with other students and staff at the Sea-ice Experimental Research Facility (SERF) at the University of Manitoba conducting oil in sea ice experiments in a special mesocosm (January-February 2017). Another funding announcement was given at the Centre for Earth Observation Science in January confirming funding commitments from Research Manitoba. A full-day consultation meeting was held at the Inn at the Forks, Winnipeg, March 19, 2017 between members of GENICE and the Canadian Coast Guard to discuss how GENICE objectives could meet the mandates and goals of the Coast Guard with respect to oil spill response preparedness.

5.5 **Arctic Science Partnership**

The Arctic Science Partnership is a formal partnership among institutions: the University of Manitoba, Aarhus University (Aarhus, Denmark), and the Greenland Climate Research Centre (Nuuk, Greenland) and associated researchers whose overarching objective is to better understand impacts of climate change and variability on Arctic regions, particularly those under the jurisdiction of Canada, Greenland and Denmark. The partnership is a direct consequence of the University of Manitoba’s CERC program and CERC Dr. Søren Rysgaard.

The ASP has generated much interest from other countries and as of the 2016 Annual meeting, the partnership includes the following new associate members:

- **GERMANY:** Alfred Wegener Institute
- **NORWAY:** UiT The Arctic University of Norway, Faculty of Biosciences, Fisheries, Economics
- **SWEDEN:** Lund University, Department of Physical Geography and Ecosystem Science
- **DENMARK:** University of Southern Denmark (SDI), Department of Biology

5.5.1 **Research**

A full list of all campaigns and projects can be found at: [http://www.asp-net.org/node/7](http://www.asp-net.org/node/7).

Sample of 2016 collaborative projects between CEOS and other ASP partners:

- Fjord winds a driver for upwelling in the fjord: Nuuk
- Carbon Cycling in fjords impacted by glaciers: Nuuk
- Light dynamics in high latitude fjord impacted by glacial meltwater input: Nuuk
- Mooring retrieving and deployment: Station North/Villum Research Station
- Baffin Bay System Study-Sanna Campaign: Northwest Greenland
- Impact of glacial meltwater on coastal carbon cycling: Northwest Greenland
- Arctic Monitoring Assessment Program: Station North/Villum Research Station
- Hudson Bay System Study (BaySys) – Fall campaign and Winter campaigns: Churchill and Nelson River Estuary, Hudson Bay
- SERF 2017
5.5.2 Emerging Large Infrastructure Initiative

Baffin Bay Observing System (BBOS) – Dr. Rysgaard leads the development of a concept paper for BBOS that has been submitted for consideration to the Canadian Innovation Fund. BBOS proposes to be a globally unique integrated bay-wide environmental observation system that will enable a sustained year round, near real-time observation of the atmosphere, ice, land and ocean at the scale of an entire ocean basin. Funding would enable large-scale integrated studies needed to understand the cascading effects from physical changes to the environment, ecosystems, and social, economic, and geopolitical conditions as well as significantly improve weather, ice hazard and environmental forecasting.

- Dr. Rysgaard led the BBOS Workshop – Ottawa, February 28-March 1, 2017.
- 60 participants from national and international academic and research institutions, government, funding agencies, northern communities, NGO’s, Inuit Circumpolar Councils (Greenland and Canada).
- Aim of the workshop is to make the case for cooperation on an observing system in Baffin Bay (rationale, challenges, benefits, and management).
- Perspectives represented: Inuit, Northern and Greenland (ICC, ITK, NTI, Nunavut Science Advisors); Canada (Polar Knowledge, ArcticNet, Meopar), International (EU, USA, ICE-PPR).

5.5.3 Workshops & Meetings

- Villum Research Station Workshop – April 2016
  - Presentation of results from Station North campaigns
- CERC meeting – Ottawa, Ontario – April, 2016
- Dr. Rysgaard represented CEOS/UM/ASP at the International Cooperative Engagement Program for Polar Research (ICE-PPR) workshops to explore military-science cooperation
  - Yellowknife – October 2016
  - Nuuk, Greenland – Spring 2017
- Dr. Rysgaard accompanied Denmark’s Prime Minister Lars Løkke Rasmussen, The President of the European Council Donald Tusk and Prime Minister of Greenland, Kim Kielsen on a climate change visit to Greenland - May 2016
  - http://www.asp-net.org/content/high-level-politicians-visit-greenland
- Dr. Rysgaard accompanied US Secretary of State Jim Kerry, Greenlandic Prime Minister, Kim Kielsen, Greenlandic Minister for Foreign Affairs, Vittus Qujaukitsoq, and Danish Minister for Foreign Affairs, Kristian Jensen on a climate change tour in Greenland – June 2016
- Dr. David Barber and Lucette Barber (ASP Communication Team) are hosted at ARC, Aarhus University, June 2-July 30
  - Numerous meetings to promote ASP with Aarhus University faculty, staff, students, and administrators
  - Visit to Nuuk to promote ASP to AWI – June 13-16, 2016
  - Promotion of ASP at University of Goteberg, Sweden – June 19-20
 Participation in Snow, Water, Ice, Permafrost in the Arctic (SWIPA) writing workshop – June 20-24
 Participate in climate change panel EUROSF, Manchester England, July 26-27

• ASP Annual Meeting – Winnipeg, Manitoba – December 1-2, 2016
  Delegates from each partner institution attended, representing the major areas of responsibility of the Arctic Science Partnership: leadership, administration, operations, communications, and education. The objective of the meeting was to enhance and strengthen the collaboration and working relationship of the partnership, and to collectively plan upcoming field campaigns.

• Arctic Changes 2016 – Winnipeg, Manitoba, December, 5-9, 2016
  Numerous presentations by ASP partners, including special sessions on Hudson Bay, and GENICE workshop.

5.5.4 Education

• Offered by ASP and Clayton H. Riddell Faculty of Environment/CEOS
• Instructors: Dr. CJ Mundy, Co-organizers: Nicolas-Xavier Geilfus (Aarhus) and Karley Campbell (CEOS/UM)
• The goal: to provide participating graduate students from ASP institutions with a strong background on the importance and current knowledge of Arctic sea ice.

5.6 Sea Ice Environmental Research Facility (SERF)
The 2017 campaign at SERF started on January 12, 2017 and ended on March 1, 2017. Experiments were conducted in the following areas:

• C-band polarimetric scattering and physical characteristics of frost-flower-covered sea ice (Dustin Isleifson and David Barber; Dustin Isleifson, David Barber, Nariman Firoozy, Ryan Galley, Jack Landy, David Binne).
• Sea ice optical properties (Jens Ehn).
• Remote sensing of a controlled crude oil spill in an artificially grown young sea ice environment (David Barber, Nariman Firoozy, Gary Stern, Monika Pučko, Puyan Mojabi, Feiyue Wang; Thomas Neusitzer, Durell Desmond, Jake Ritchie, Marcos Lemes, Zhantang Xu, Kedong Zhang, Diana Chirkova, Dustin Isleifson).

In addition, film crews from NHK (Japan Broadcasting Corporation) and BBC (British Broadcasting Corporation) visited SERF for filming and interviews.
5.7 Plains Elevated Convection at Night (PECAN)

The Plains Elevated Convection at Night (PECAN) project was designed to improve the understanding of thunderstorms at night over the continental United States. Fourteen universities and eight research laboratories participated in the campaign, which was conducted in Oklahoma, Kansas, and Nebraska from June 1 to July 15, 2015. On-going research is jointed funded by US agencies: NSF, NOAA, NASA, and Department of Environment (DOE).

PECAN has four major objectives:

1. To advance the explanation of environmental characteristics and processes leading to nocturnal convection initiation and the early phases of large-scale storm clusters.
2. To increase our understanding of the internal structure and microphysics of large-scale nocturnal storm clusters.
3. To further knowledge of wave-like disturbances caused by convective storms.
4. To improve prediction of nocturnal convection, which will aid in improving operational forecasting and climate models.

Dr. John Hanesiak, along with two CEOS graduate students (Scott Kehler and Kyle Ziolkowski) participated in the six-week field project. The collected field data was used for the students’ master’s projects.

PECAN research continued during the 2016-17 reporting period, with the completion of Scott Kehler’s Master’s work (and successful defence) titled “Cases of Elevated Deep Moist Convection Initiation Above Frontal Surfaces in 2015”. A peer-reviewed manuscript based on this work will be submitted to Weather and Forecasting (American Meteorological Society (AMS) journal) in winter 2017-18. Scott’s work provided some new insights into how nocturnal summer storms initiate ahead of warm fronts, an issue that continues to plague even the most experienced weather forecasters. The other Master’s student (Kyle Ziolkowski) working on PECAN continues to complete his research and degree, with the hopes of defending sometime in early 2018. Kyle’s work focuses on how nocturnal boundary layer bores initiate warm season elevated convection, another major issue concerning forecasting severe convection that occurs at night.

5.8 The Analytical Quandry of Chert Quarries

This is a new five-year fieldwork based project led by Dr. Brooke Milne, and funded by a SSHRC Insight Grant and a logistical support grant through the Polar Continental Shelf Project (PCSP). The project builds on the most significant results of Milne’s archaeological research over the last 20 years on southern Baffin Island. The objectives of the project are to ground-truth a GIS model of prospective travel routes connecting the island’s coast and interior regions; to identify and characterize additional chert quarries in the interior to build on our existing geochemical database for this tool stone in the eastern Arctic; and, to understand how lithic reduction and use strategies, including novice skill acquisition, was organized across the landscape for the Pre-Dorset and Dorset populations that lived there. The project incorporates a multi-methods approach integrating GIS, archaeo-geophysics, lithic provenance, and lithic debitage analysis. The first field season is scheduled for summer 2018.
• Social Sciences and Humanities Research Council of Canada, Insight Grant Program
• Amount: $283,666
• Role: Principal Investigator
• Date: 2017–2022
• Title: The Analytical Quandary of Chert Quarries: A Multi-Scalar Approach using GIS Modelling, Archaeo-Geophysics, Lithic Provenance, and Debitage Analysis to Understand Palaeo-Eskimo Lithic Technological Organization and Novice Skill on Southern Baffin Island.

5.9 Using LEXT Laser Microscopy to Identify Enamel Surface Defects in Archaeological Caribou Dentition

This project builds on the results of a previous project led by Dr. Brooke Milne to investigate enamel surface defects among human teeth dating to the Danish Medieval Period (Gamble & Milne, 2016). The LEXT microscope is a new technological application used to investigate microscopic surface defects in teeth to understand growth patterns in individuals and how certain forms of stress may impact their development and quality of life with aging. Caribou have been an essential material and subsistence resource for human populations in the Arctic for millennia. Having large, well-preserved faunal assemblages from the interior southern Baffin Island sites that have been investigated since 2004, provided the opportunity to test this analytical method on a previously collected caribou tooth. In this first application of the LEXT microscope, Milne’s team was able to identify diagnostic indicators for developmental stress in their caribou specimen. They were invited to contribute a paper presenting their findings in a special volume of the Journal of Archaeological Science: Reports (Gamble & Milne, forthcoming). The results will serve as the foundation for a future SSHRC Insight Grant application that will be founded on applying this analytical and diagnostic method to a larger study sample to understand how resident caribou herds on southern Baffin Island were impacted by various forms of stress. In turn, this new information will provide insights on how human populations in this region were impacted over time by the health and stability of this essential animal resource.


5.10 The Southampton Island Marine Ecosystem Project (SIMEP)

This is a new three-year multi-disciplinary project funded (2017) by the National Centres of Excellence Program – MEOPAR (Marine Environmental Observation Prediction and Response), the Manitoba Centres for Excellence, Polar Canada, and the Arctic Research Foundation. Project lead is C.J. Mundy, and co-investigators include Drs. B. Milne, J. Ehn, with collaborators including D. Barber, I. Dmitrenko, Z.Z. Kuzyk, T. Papakyriakou, S. Ferguson, K. Hedges, C. Michel, and T. Brown. The overall project aims to investigate the importance, role, and stability of populations of marine mammals available near Southampton Island on the development and sustainability of human populations over the last 2500 years. Ecosystem structure, function and stresses in the marine environment will be investigated with an aim to provide information on the annual operation of biophysical processes and the timing, location, and fate of production at different trophic levels of the ecosystem. Data collection will involve the use of moorings and ship-based surveys.
Dr. Milne will conduct archaeological survey and site testing in the summer of 2018 to acquire preserved faunal remains and artifacts from archaeological sites identified on Southampton Island’s southeastern shore. Using zooarchaeological analysis — the archaeological analysis of animal remains — Milne’s team will examine newly acquired faunal remains as well as those collected in the 1950s and 1980s to gain an understanding of diversity of subsistence resources that were harvested and how these may have changed over time. This fieldwork and analysis will add an important long-term human dimension to the larger SIMEP project. Moreover, given the occupation of Arctic Manitoba by the same cultural populations as those found on Southampton Island, interpretations drawn from the SIMEP project in terms of human responses to climate change in the past, including shifts in land use and subsistence practices, will be important for comparative interpretations of human-environment interactions in northern Manitoba and, more broadly, the entire Hudson Bay marine environment.

- Marine Environmental Observation Prediction and Response (MEOPAR), National Centres of Excellence Program.
- Amount: $399,000
- Date: 2017–2020
- Title: Southampton Island Marine Ecosystem Project (SIMEP)

5.11 Manitoba Great Lakes Project

CEOS is a founding member of the Lake Winnipeg Research Consortium (LWRC). With funding from a Canadian Space Agency GRIP (Government Related Initiatives Program) Grant, in partnership with the Canadian Department of Fisheries and Oceans, we continued a study of the potential use of satellite remote sensing data to improve algorithms for chlorophyll measurement and to discriminate cyanobacteria from other phytoplankton in Lake Winnipeg.

Zooplankton sampling in Lake Manitoba, August 2017. ©Whitney Light.
The overarching goal of the Manitoba Great Lakes Project (MBGL) 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. In the past, this work 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, animal husbandry and lack of adequate sewage treatment in the watershed.

With three moorings collecting in situ data (chlorophyll A, phycocyanin, turbidity, temperature, and pressure) 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.
- Evaluate the anthropogenic impact on Manitoba’s freshwater ecosystem.
- Develop an understanding of how nutrients and contaminants move throughout the 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 2017, the Lake Winnipeg Foundation provided $6000 of support for the graduate work on the lakes.

Two moorings were also deployed into Lakes Manitoba and Waterhen. The graduate project by Claire Herbert with supervisor Dr. David Barber continued. Community-based monitoring initiative in conjunction with the Lake Winnipeg Foundation also continued.

16 stations from Lake Manitoba, 10 from Lake Winnipegosis and 3 from Lake Waterhen were collected and analyzed for:

- Phosphorous - suspended and particulate
- Nitrogen - particulate and dissolved
- Carbon - inorganic and dissolved
- Chlorophyll and phaeophytin
- Total suspended solids (TSS)
- Suspended organic matter (LOI)
- Conductivity
- pH
- N fixation
- αP
• CDOM (Coloured dissolved organic material)

Samples for algal and zooplankton identification and algal toxin analysis were also preserved.


### 5.12 Canadian Watershed Information Network

**Coordinator:** Claire Herbert

The Lake Winnipeg Basin Information Network (LWBIN) was renamed the Canadian Watershed Information Network (CanWIN) to reflect its revised mandate to collect research data within the Nelson River watershed and any Arctic research associated with CEOS.

CanWIN has continued its partnership with the Lake Winnipeg Foundation (LWF), through hosting the LWF’s Community Based Monitoring project data as well as through funding the LWF provided for CanWIN to host their Netley-Libau Marsh Project.

A whitepaper describing the revised framework for the CanWIN has been produced. A developer continues to work on the datahub ([http://lwbin-datahub.ad.umanitoba.ca/](http://lwbin-datahub.ad.umanitoba.ca/)) of CanWIN to facilitate the needs of research projects at the University. In conjunction with IST, a new geoserver has been installed and is in beta version ([https://geonodedev.ad.umanitoba.ca/](https://geonodedev.ad.umanitoba.ca/)).

CanWIN also became part of the Consortium for Arctic Data Interoperability (CCADI) as the data node for the University of Manitoba. The 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.

CanWin is also a member of the Research Data Alliance Research Data Repository Interoperability Working Group (https://www.rd-alliance.org/groups/research-data-repository-interoperability-wg.html).

6 Financial Information

6.1 Grant Funding
Table 1 shows all research grants (dollars and/or value in kind) that were obtained or held during the reporting period, and Figure 1 shows a chart breaking down the research grants by funding type.

![Figure 1: Chart showing research grants by funding type.](image-url)
Table 1: Research grants obtained or held during 2016-2017 reporting period.

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<td>319152</td>
<td>ANet SF Training Fund Ritchie</td>
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<td>NSERC CRDPJ 470028-14 317696 Kuzyk</td>
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<tr>
<td>Wang</td>
<td>319257</td>
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</tr>
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<td>Ehn</td>
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<td>Barber</td>
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<td>Kuzyk</td>
<td>319373</td>
<td>Research Manitoba MCEF Kuzyk MEOPAR</td>
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6.2 Northern Scientific Training Program (NSTP)

Table 2 shows all CEOS students who received NSTP funding in 2016-17.

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<th>Amount</th>
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<td>Laura Dalman</td>
<td>C.J. Mundy</td>
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<td>Cassandra Debets</td>
<td>Steve Ferguson</td>
<td>$3,500.00</td>
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<tr>
<td>Nicole Pogorzelec</td>
<td>C.J. Mundy</td>
<td>$3,500.00</td>
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<tr>
<td>Marianne Marcoux</td>
<td>Steve Ferguson</td>
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</tr>
<tr>
<td>Alana Wilcox</td>
<td>Steve Ferguson</td>
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<td><strong>Total:</strong></td>
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<td><strong>$17,500.00</strong></td>
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6.3 Summarized Annual Operating Budget
A summary of the annual operating budget is shown in Table 3. Details can be found in Appendix A. Figure 2 shows a breakdown of the operating budget expenditures by category.

![Operating Budget - Annual Total $50,0136.73](chart.png)

Figure 2: Chart showing breakdown of operating budget expenditures by category.

<table>
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<tr>
<th>Item</th>
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<td>2</td>
<td>Travel</td>
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<td>3</td>
<td>Materials, Supplies &amp; Services</td>
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<td>Utilities, Taxes &amp; Insurance</td>
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<td>5</td>
<td>Professional &amp; External Services</td>
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<td>6</td>
<td>Repairs &amp; Maintenance</td>
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<td>7</td>
<td>Capital Asset Acquisitions</td>
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<td></td>
<td><strong>Total</strong></td>
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<td><strong>100</strong></td>
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7  Academic Contributions
CEOS researchers published 54 peer-reviewed journal articles during the reporting year. CEOS members also presented a number of posters at various workshops and conferences, and delivered a number of oral presentations and invited lectures.

Only contributions for the reporting period are listed. Previous years’ contributions can be found in past annual reports.

7.1  Primary Publications (C.1): April 1, 2016 – March 31, 2017
The following is a list of peer-reviewed research articles published by CEOS researchers that fall within the April 1, 2016 – March 31, 2017 reporting period. A full list of articles from the last six years can be found on the CEOS website: http://umanitoba.ca/ceos.

2016 (April – December)


30. Pleskach, K., Hoang, W., Chu, M., Haldorson, T., Loseto, L.L., Ferguson, S., Tomy G. (2016) "Use of mass spectrometry to measure aspartic acid racemization for ageing beluga


2017 (January – March)


7.2 Non-Refereed Contributions (E.2)

7.2.1 Book Chapters

7.2.2 Poster and Oral Presentations
The following is a selection of poster and oral presentations during the 2016-2017 reporting period.

**Society for American Archaeology Annual Meeting, Vancouver, BC, March 29-April 2, 2017**


**European Geosciences Union General Assembly 2016 (Vienna, Austria, 17-22 April 2016)**


Canadian Meteorological and Oceanographic Society's 50th Congress and Canadian Geophysical Union Meeting. Fredericton, NB, May 29 - 2 June 2016


39th AMOP Technical Seminar on Environmental Contamination and Response – June 7-9, 2016, Halifax, NS

**SETAC Prairie Northern Regional Chapter - Toxicology in the 21st Century: Applications of Prairie Research – June 15-16, 2016 Saskatoon, SK**

- Lau, C., Moore, D., and Hanson, M. (2016) “The duckweed *Lemna minor* recovers following 7, 14, 21, and 28 days exposure to atrazine environmental concentration”. (Poster)
- Lobson, C. and Hanson, M. (2016) “Aquatic insects as a mechanism of dispersal for antibiotic resistance genes in the environment”. (Poster)
- Reeves, A., Lobson, C., Challis, J., and Hanson, M. (2016) “Are aquatic snails reservoirs and vectors of microbes bearing antibiotic resistance genes?”. (Poster)
- Vanderpont, A. and Hanson, M. (2016) “Constructing species sensitivity distributions for lead (Pb) from the ECOTOX database: lessons and limitations for reliability and relevance”. (Poster)

**ArcticNet Annual Scientific Meeting 2016 – December 5-9, Winnipeg, MB**

- Andrews, J., Babb, D., and Barber, D. “Climate change and sea ice: Marine shipping access in Hudson Bay and Hudson Strait (1980-2014)”. (Poster)
• Campbell, K., Mundy, C.J., Landy, J., Delaforge, A., and Rysgaard, S. (2016) “Community dynamics of bottom-ice algae in Dease Strait of the Canadian Arctic”. (Poster)
• Kenyon, K., Yurkowski, D., Ferguson, S., Barber, D., and Orr, J. (2016) “Narwhal habitat selection within their wintering ground”. (Poster)
• Landy, J., Ehn, J., Babb, D., Theriault, N., and Barber, D. (2016) “Sea ice thickness in the eastern Canadian Arctic”. (Poster)
• Liu, Z., Lukovich, J., Kirillov, S., and Barber, D. (2016) “Modeling study on Hudson Bay using the NEMO ice-ocean model”. (Poster)


• Matthes, L., Mundy, C.J., Lambert Girard, S., Hodgson, R., Verin, G., Babin, M., and Ehn, J. (2016) “Spring progression of spectral light transmission through landfast sea ice during the melt season on the Arctic continental shelf of Baffin Bay”. (Poster)


• Noel, A., Li, C., Stacey, D., Gittins, D., and Hubert, C. (2016) “Marine microbial hydrocarbon degradation in the Kitikmeot region: are the microbial responses and communities the same as elsewhere in the Arctic?”. (Poster)

• Ogi, M., Rysgaard, S., Barber, D.G., Nakamura, T., and Taguchi, B. (2016) “Is summer sea surface temperature over the Arctic Ocean connected to winter air temperature over North America?”. (Poster)


• Watts, M., Barber, L., and Barber, D. (2016) “Schools on Board field program: examining the impacts of ArcticNet’s outreach program on students and teachers”. (Poster)


• Campbell, K., Mundy, C.J., Gosselin, M., Landy, J.C., Delaforge, A., Rysgaard, S. (2016) “Net community production in the bottom of Arctic sea ice over the spring bloom”. (Poster)

• Galindo, V., Gosselin, M., Mundy, C.J., Ferland, J., Delaforge, A., Campbell, K., Raimbaud, P., and Rysgaard, S. (2016) “Differences in production regime in two simulated under-ice blooms during the Arctic spring”. (Poster)


**American Geophysical Union (AGU) 2016 Fall Meeting, 12-16 December 2016, San Francisco, CA**


**24th International Lightning Detection Conference and 6th International Lightning Meteorological Conference, 18-21 April 2016, San Diego, CA**


7.2.3 Invited Talks


• Ali, G. (2016). “When the exception becomes the rule: how (un)useful are traditional hydrological theories in the Canadian prairies?”, Young Hydrologic Society Workshop, May 29, 2016, Fredericton, NB, Canada.


• Barber, D.G. (2016). “Challenges and Opportunities of a Rapidly Changing Arctic”, Centrallia: Global B2B Forum, Winnipeg, MB, 25-27 May 2016. During this conference, we highlighted business opportunities focused on servicing the needs of northern communities and improving economic conditions, such as: energy, communications, waste management, transportation and logistics, food security, new technologies.

• Rysgaard, S. (2017). “CERC in Arctic Geomicrobiology and Climate Change”. Oral presentation at the Canada Excellence Research Chair (CERC) Summit, Dalhousie University, August 17-18, Halifax, Nova Scotia; Canada.
• Stewart, R. (2016). “Hazardous Winter Precipitation”, Canadian Meteorological and Oceanographic Society (CMOS) Lecture Tour, University of Northern British Columbia; University of British Columbia, University of Victoria, University of Alberta, Environment & Climate Change Canada (Edmonton & Winnipeg), and University of Saskatchewan.
## A Detailed Budget By Account Code

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<td>$5,673.12</td>
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**Utilities, Taxes and Insurance**

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Subtotal $121.00

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Subtotal $1,896.48

**Capital Asset Acquisitions**

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Subtotal $1,945.17

**Repairs and Maintenance**

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Subtotal $1,964.97

**Student Awards**

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