

THE RESEARCH STRENGTHS OF UNIVERSITÉ LAVAL IN THE ARCTIC FIELD

1. Institutional strategic research plan. By hosting four research centers with a northern mandate, Canada's only Arctic Network of centres of excellence, and major infrastructures dedicated to northern sciences (including the Canadian research icebreaker *Amundsen*), Université Laval supports and coordinates the research effort of a pan-Canadian network of over 220 northern specialists, their students and their international collaborators. "Northern studies and oceanography" are thus one of the eight research priorities of Université Laval: *"The Far North and Arctic regions are vast fields of study that have been of interest to researchers at Université Laval for a number of years. Their activities have positioned Laval as an international leader in northern studies and oceanography. Research activities are based on an interdisciplinary approach involving geographers, ethnologists, geologists, biologists, botanists, geophysicists, climatologists, and health professionals, who teamwork in regions where natural processes related to cold climatic conditions are particularly observable."*

2. Research centres and Networks of centres of excellence. Since the 1960's, Université Laval has continuously invested in Northern research through its funding of four complementary research centres that collectively support the efforts of ca. 45 of its professors and hundreds of students in different departments. Recently, these investments have amplified spectacularly as Laval hosted two Arctic research networks, the North Water Polynya Study (NOW) and the Canadian Arctic Shelf Exchange Study (CASES), the Network of Centres of Excellence (NCE) ArcticNet, the *Amundsen* and arctic research stations (Sustaining Arctic Observing Network at Centre d'Études Nordiques, SAON-CEN), bringing an overall total of nearly \$166M in grants that have been redistributed through our pan-Canadian network of northern specialists. The northern research capacity assembled over the years at Université Laval is now unmatched elsewhere in academia in Canada or abroad.

- **ArcticNet** (www.arcticnet-ulaval.ca). Hosted at Université Laval, the NCE ArcticNet brings together scientists and managers in the natural, human health and social sciences with their partners in Inuit organizations, northern communities, federal and provincial agencies and the private sector for the integrated study of the impacts of climate change and modernization in the coastal Canadian Arctic. Over 110 ArcticNet researchers from 27 Canadian universities and 5 Federal departments collaborate with research teams in the USA, Japan, Denmark, Sweden, Norway, Poland, the United Kingdom, Spain, Russia, Greenland and France. By funding over 30 research projects meshed in four Integrated Regional Impact Studies (IRIS) and supporting many other projects under the umbrella of the International Polar Year, ArcticNet is spearheading the on-going revitalization of Canada's scientific role in the Arctic.
- **Québec-Océan** (www.quebec-ocean.ulaval.ca). Québec-Océan mobilizes the resources and the creativity of Québec researchers to develop excellence in oceanographic research and training, pooling scientific equipment, technical expertise, and intellectual and financial resources from its members. With its core Fonds Québécois de la recherche sur la Nature et les Technologies (FQRNT) funding renewed in 2008 for 6 years at an enviable level, Québec-Océan is pursuing its ambitious program on the function and integrity of Arctic and subarctic marine ecosystems of ice-covered seas under climate change. One of ArcticNet's centres of excellence, Québec-Océan led the scientific mobilization of the research icebreaker Canadian Coast Guard Ship (CCGS) *Amundsen* (section 12) for research on sea ice, the physics and chemistry of marine waters, optics, bathymetry, geology, food web ecology, ocean-atmospheric exchanges and molecular microbiology. The proposed Chair would be a member of Québec-Océan.
- **Centre d'études nordiques** (CEN: www.cen.ulaval.ca). CEN is one of North America's leading research centres of excellence for the study of high latitude climate, landscapes, aquatic environments, vegetation and wildlife. It focuses on three research themes: (1) structure and function of geosystems and ecosystems across the ecozones of eastern Canada; (2) evolution of these systems in the context of climate change and accelerated development; (3) vulnerability and risks associated with environmental change and adaptation strategies. An ArcticNet centre of excellence, CEN operates the SAON-CEN array of eight northern research stations (section 12) including the Kuujuarapik facility that is operated throughout the year. The centre works closely with Cree and Inuit communities and has a strong commitment to public outreach and education..
- **Centre interuniversitaire d'études et de recherches autochtones** (CIÉRA : www.ciera.ulaval.ca). CIÉRA brings together academic researchers studying Native People of the world, the North, and circumpolar regions and training students in Native, northern, and circumpolar issues. CIÉRA research program comprises four

major axes: historico-cultural, socio-economic, politico-legal and education and training in an intercultural environment. The centre publishes its own collection *Travaux de recherche* and collaborates with the Inuksiitit Katimajit Association to publish the international *Études/Inuit/Studies*. Since 1989, CIÉRA maintains Banque Métrinord, ArcticStat and Nunivaat, three databases on arctic Quebec. CIÉRA and CEN have recently established a formal Memorandum of understanding (MoU) between Université Laval and the University of Alberta, which will facilitate new Arctic.

- **Nasivvik Centre for Inuit Health and Changing Environments** (www.nasivvik.ulaval.ca). Based at the Public Health Research Unit of Université Laval medical research centre, Nasivvik (Inuktitut for “vantage point”) participates in the Aboriginal Capacity and Developmental Research Environments (ACADRE) of the Canadian Institutes of Health Research. The Centre focuses on contaminants in the northern environment and food chain and their impacts on health; the direct and indirect effects of the changing northern climate on individual and community health; and relationships with chronic diseases among Inuit populations. It emphasizes the development and application of methods to use Inuit knowledge in health research and action, and promotes the use of traditional Inuit plants and medicines. Québec-Océan and CEN collaborate with Nasivvik through the program ArcticNet, for example on the implications of climate-induced changes in marine food webs for human nutrition in the North.

3. Research chairs (www.chairs-chaieres.gc.ca). In addition to research centers and NCEs, Université Laval has allocated a remarkable thirteen chairs devoted in part or fully to Northern studies. Of the thirteen, the first three listed here are most directly related to Northern studies and oceanography:

- **Fortier, Louis** (Biology). Canadian Research Chair (CRC) in Arctic Oceanography (Tier 1). Scientific Director of ArcticNet; Scientific Leader for the Research Icebreaker *Amundsen*; founding Director of Québec-Océan; and internationally acclaimed leader of Canadian Arctic oceanography. Dr. Fortier initiated and brought to fruition many large-scale investments totalling over 140M\$ to rebuild Canadian infrastructure and leadership in Arctic research. Recipient of numerous awards for his public and scientific leadership, including the Order of Canada (2007) and l’Ordre national du Québec (2008);
- **Levasseur, Maurice** (Biology). CRC in Ocean Biogeochemistry (Tier 2). Director of Québec-Océan; International Director of Surface Ocean Lower Atmosphere Study (SOLAS); Principal Investigator of Arctic-SOLAS; highly respected and well cited biological oceanographer, with many international collaborations;
- **Vincent, Warwick** (Biology). CRC in Aquatic Ecosystem Studies (Tier 1). Director of CEN, member of the Royal Society of Canada (RSC) and New Zealand (RSNZ); former chair of many NSERC committees including Group Chair in the Environmental Sciences (2005-8); recipient of many teaching and research awards including the 2008 Miroslaw Romanowski Medal (RSC) for environmental research achievements in the Arctic and Antarctica;
- Bernatchez, Louis (Biology). CRC on Genomics of Aquatic Resources (Tier 1) at Québec-Océan;
- Côté Steeve (Biology) NSERC Anticosti Industrial Research Chair at CEN;
- Desbiens Caroline (Geography). CRC in Historical Geography of the North (Tier 2);
- Duhaime, Gérard (Sociology). CRC on Comparative Indigenous Conditions (Tier 1), and Louis-Edmond-Hamelin Chair on Northern Research in Social Sciences at CIÉRA;
- Halley, Paule (Law). CRC in environmental law (Tier 2), appointed as Special Counsellor to the Commission for Environmental Cooperation in charge of implementing an agreement on the environment parallel to the North American Free Trade Agreement (NAFTA), also works with the United Nations;
- Konrad, Jean-Marie (Civil engineering). NSERC Industrial Chair on Infrastructure and Freezing;
- Lavoie, Martin (Geography). CRC on Long Term Boreal Forest Dynamics (Tier 2) at CEN;
- Payette, Serge (Biology). NSERC Northern Research Chair (senior) at CEN;
- Rochefort, Line (Phytology). NSERC Industrial Research Chair in Peatland Management at CEN;
- Ruel, Jean-Claude (Forestry). NSERC Industrial Chair on Boreal Forest Flora and Fauna

Geomatics is also a major strength at Université Laval, and the Faculté de foresterie et géomatique includes Dr. Yvan Bédard, who holds the NSERC Industrial Research Chair in Geomatics. Bédard is a renowned international researcher in the development of fast technologies for spatial data analysis via online systems, specifically his development of the Spatial Online Analytical Processing (SOLAP). For additional key researchers, see sections 4 and 5.

4. Key researchers from Quebec-Ocean and their interests in relation to the chair. In addition to the 13 chair holders listed in section 3, the following key researchers will probably be involved in the same projects as the chair. From Université Laval: (1) microbiologist **Connie Lovejoy**, NSERC University Faculty Awardee and her team have discovered the Picobiliphytes, marine picoplanktonic algae with unknown affinities to other Eukaryotes (Science 2007); (2) biologist **Jean-Éric Tremblay**, a rising star in polar oceanography, works on arctic primary production, nutrient cycling and biogeochemical fluxes; From McGill University: (3) high latitude and climate change specialist **Bruno Tremblay**, editor of Journal of Geophysical Research - Océans, associated research scientist at Lamont Doherty Earth Observatory, particularly interested in sea ice / snow blowing and climate variability, high latitude paleo-climate, sea ice modeling; From Université du Québec à Rimouski: (4) recently recruited **Simon Bélanger**, **Daniel Bourgault** and **Dany Dumont** focus respectively on carbon fluxes, organic matter, ocean color and teledetection; observation and simulation of internal waves and turbulence in coastal seas and arctic regions; ice circulation modelling in the Arctic Archipelago (marginal ice zone and land-fast ice). From Institut National de Recherche Scientifique: (5) physical oceanographer **Yves Gratton**, core data expert in most Arctic NSERC Research Networks.

5. Other key researchers and most important research contributions. the following key northern specialists are based at Université Laval: (1) renowned permafrost expert Michel Allard (recipient of the prestigious Centennial International Polar Year Northern Science Prize, 2007) maps the risks associated with building on unstable permafrost in northern communities such as Salluit; (2) epidemiologist Éric Dewailly, Director of Nasivvik and world leading researcher in Inuit health studies has led the *Amundsen*-based health survey *Qanuippitaa? (How are we?)* that has revealed the alarming deterioration of the physical and mental condition of the Inuit of the Nunavik; (3) anthropologist Frédéric Laugrand leads the CIÉRA center which conducts world-leading studies on the adaptation of Inuit communities to change; (4) paleolimnologist Reinhard Pienitz, ranked as one of Québec City's 22 most outstanding achievers by *Actualité*, uses fossil indicators from northern lakes and Arctic coastal seas to reconstruct the climate of the Holocene; (5) geologist Patrick Lajeunesse described the sudden emptying 8470 years ago of the immense glacial lake Agassiz-Ojibway that covered Hudson Bay (Nature Geoscience 2008); (6) ornithologist Gilles Gauthier has tracked the population dynamics of the Greater Snow Geese on Bylot Island in response to climate over the last 20 years.

6. Space, infrastructure, labs, supercomputing platform, libraries, databases. Université Laval provides extensive office space for the secretariats of all four research centres listed above, and for ArcticNet. It also supports the broad spectrum of laboratories for advanced environmental and data analysis, including separate facilities for research in arctic plankton ecology, polar molecular oceanography, polar marine and freshwater ecology, arctic climatology, arctic paleo-ecology, northern vegetation ecology, northern fish genomics, northern wildlife ecology, northern seas biogeochemistry, ocean gas flux processes. Université Laval is part of CLUMEQ, a research consortium for high-performance computing (HPC). A supercomputing platform is based at Laval, where CLUMEQ provides support and training to researchers (www.clumeg.ca). Université Laval has also undertaken a major investment program in its digital library facilities over the last ten years, and has access to all major online journals and databases.

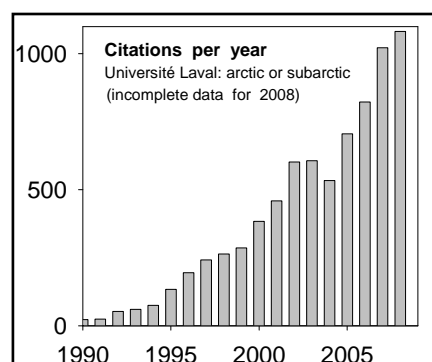
However, by far the most important investments of Université Laval in northern research have been in support of two major infrastructures funded by the Canadian Foundation for Innovation (DFI): the Research Icebreaker *Amundsen* and the SAON-CEN network of Arctic observing stations, which are described in section 12.

7. Technical support. Université Laval also invests substantially in the technical services provided by each of the research centres. For Québec-Océan as well as Centre d'études nordiques this includes the insurance and renewal of oceanographic equipment, the salary of the central technician, the maintenance of equipment and the rental of an industrial workshop. This university support leverages considerable funds from other sources. For example, Québec-Océan is granted from FQRNT (provincial) and from NSERC to support its team of 9 technicians and 4 clerical staff that maintain its extensive pool of oceanographic equipments.

8. Training programs. In recent years, the Department of biology (www.bio.ulaval.ca) has proceeded with a full revision of the undergraduate teaching of ocean sciences and the development of a PhD in oceanography. In both biology and geography, undergraduate and graduate courses are strongly biased towards northern issues, providing students with a unique arctic-oriented curriculum. For example, Fortier's *Physical Oceanography*, Tremblay's *Marine Ecosystems*, Vincent's *Limnology: Dynamic Aquatic Ecosystems*, and Pietnitz's *Paleoclimates* all focus on climate change and the functioning of northern marine and freshwater ecosystems. The same apply to terrestrial ecology and anthropology.

9. National and international collaborations. Arctic specialists at Université Laval have an impressive record in leading and contributing to large national and international multidisciplinary collaborations. At the international level, they led the International NOW Study (1997-2001) and CASES (2001-2007), two major Research networks funded by the NSERC. At the Canadian level, the Laval-based NCE ArcticNet represents the most intense and integrated research effort in the Arctic with 28 projects participating in 4 IRIS studies (see section 2). As part of the IPY (2007-2009), ArcticNet Investigators lead or co-lead 11 of the 44 projects funded by the Federal program and 6 of the 11 NSERC-funded projects. Researchers at Laval contribute to a majority of the 44 Federal programs, and lead the Arctic WOLVES (Impact of Climate Change on Tundra Wildlife), Microbial Biodiversity of High Arctic Ecosystems (MERGE), Arctic Surface Ocean Lower Atmosphere Study (Arctic-SOLAS), and the Integrated Research Program on Arctic Marine Fat and Lipids programs. In particular, Laval-based researchers participated massively in the six IPY programs supported by the *Amundsen*, including the Circumpolar Flaw Lead System Study (CFL, www.ipy-cfl.ca) and the Inuit Health Surveys “Qanuipitali ?”, the two largest components of the Canadian IPY effort. Finally, as part of the International Partnership Initiative of ArcticNet, Laval-based researchers are major players in the USA-Russia-Canada-UK-Germany international Nansen-Amundsen Basin Observatory System (NABOS) and the French-led MALINA, an international study of Arctic Ocean photochemistry and photobiology conducted on the *Amundsen*.

10. Citation statistics. Université Laval's top northern researchers are highly cited, with an h-index of 20 and above, and total citations per person of >1000. Furthermore, many faculties in northern science, including recently engaged professors, show steep upward trends in their citation rate and h-index. For Université Laval overall, the Web of Science citation report for the keywords Univ Laval (address) and arctic/subarctic (topic) gives an h-index of 41 (this analysis is conservative because it excludes books, technical reports and review chapters, which are often heavily cited); a value of 45 could be considered at the level of membership in the United States National Academy of Sciences (Hirsch JE 2005 An index to quantify an individual's scientific research output. PNAS 102: 16569–72). Over the last 18 years (see graph), our citation rate in these topic areas has risen sharply, with a current value (2007 and 2008) of >1000 citations per year.



11. Training of HQP. Université Laval has a huge commitment to research trainees (HQP), and two of its strongest training areas are Ocean Sciences and Northern Sciences. The following Table is for these two areas, from the Québec-Océan and Centre d'Études Nordiques databases (Université Laval only). **CE** = current enrolments as at 1 December 2008. There is no overlap between data for the two research areas.

HQP	Graduated or postdoctoral studies completed (in parentheses: number of scholarships held per year)					CE	Totals
	2004	2005	2006	2007	2008		
Québec-Océan							
MSc	8 (8)	6 (6)	9 (4)	9 (4)	6 (7)	27	65 (29)
PhD	4 (10)	5 (7)	2 (7)	4 (6)	2 (7)	28	45 (37)
Postdoc	2 (2)	2 (1)	1 (0)	3 (1)	0 (1)	4	12 (5)
Centre d'études nordiques (CEN: Centre for Northern Studies)							
MSc	15 (8)	10 (4)	18 (9)	12 (6)	6 (19)	48	109 (46)
PhD	5 (4)	9 (10)	2 (3)	5 (5)	7 (24)	29	57 (46)
Postdoc	4 (1)	3 (1)	2 (1)	2 (1)	1 (2)	6	18 (6)

Another measure of the Canadian standing of graduate students in the Northern studies at Université Laval is their success in the federal Northern Studies Training Program (INAC). Each year, Université Laval has the largest number of applicants and has won the largest fraction of support relative to any other Canadian university: for the period 2002 to 2008 the total NSTP budget for 40 universities was \$5 648 248, of which 12% went to students at Laval (average grant per institution was 2.5% of this total). In addition to these northern strengths,

12. Quality and suitability of facilities. The Canadian Research Icebreaker Amundsen and the SAON-CEN network of Arctic observing stations, two international polar research facilities are hosted by Université Laval that provide access to the Arctic and exceptional training and research environments:

- **The Canadian Research Icebreaker Amundsen** (www.amundsen.ulaval.ca) is a national facility with an international mandate hosted at Université Laval and operated jointly by Québec-Océan, ArcticNet and the Canadian Coast Guard. The 98-m long, 6000-ton displacement, 14000-HP icebreaker was mobilized for science in 2003 thanks to a \$27.5M grant from the CFI and investments from the Department of Fisheries and Oceans Canada in excess of \$3M to retrofit the ship. It has become a major catalyst to re-energize Canadian Arctic science by giving Canadian oceanographers, climatologists, geologists, terrestrial ecologists, and epidemiologists and their international collaborators unprecedented access to the Arctic Ocean. The initial \$9M pool of scientific equipment attached to the ship was expanded in 2006 thanks to an additional \$10.8M grant from the Leading-Edge Fund of the CFI and major contributions from Université Laval. The community of users has succeeded in securing over \$38M to deploy the icebreaker for a total of 1006 days at sea since 2003, which exceeds by 23% the optimistic 818 days of use anticipated in the original proposal to the CFI.



“Funding from the Canada Foundation for Innovation (CFI) has enabled a complete overhaul and refitting of the CCGS *Sir John Franklin*, renamed the CCGS *Amundsen*, a “state of the science” facility arguably superior to any existing arctic science icebreaker in the world.”
Beacons of the North: Research Infrastructure in Canada’s Arctic and SubArctic
 Canadian Polar Commission, June 2008.

- **The SAON-CEN network of Arctic observing stations.** Université Laval also manages, through Centre d’études nordiques, the SAON-CEN network of eight research stations for terrestrial and coastal aquatic research. This network (right) extends over 4000 km, from a reference site near Québec City to Ward Hunt Island at latitude 83N, at the edge of the Lincoln Sea. The network includes a research station with CFI-upgraded laboratories at Kuujuarapik that has been used for coastal oceanographic studies in Hudson Bay in the past, and it would be a suitable base for some future operations. The CFI-funded observatory at Ward Hunt Island offers access to far northern fjords and coastal environments that are currently experiencing dramatic impacts of climate warming.

