

Brief Biographic Sketch (November, 2009)

R. W. Macdonald

Not Relevant

EDUCATION

Ph.D. Dalhousie University, 1972

B.Sc. (Hon). Dalhousie

University Medal in Chemistry

Society of Chemical Industry Merit Award

Chemical Institute of Canada Prize

BRIEF RESUME

My oceanographic and geochemical research during the past 35 years falls under three major subjects: the cycling of organic carbon in the ocean, the cycling of freshwater in the Arctic Ocean, and contaminant pathways in temperate and polar aquatic systems. During the past decade, the boundaries between my fields of research have somewhat collapsed: it has become clear to me that organic carbon, freshwater and contaminants all interact with one another in ways that sometimes provide simplicity, sometimes complexity, but always reveal key processes where climate change can operate.

For organic carbon, much of my research is founded in the application of biomarkers (e.g., lignins, alkanes, PAH, sterols), stable isotopes ($\delta^{13}\text{C}$, $\delta^{15}\text{N}$) and $\Delta^{14}\text{C}$ to determine sources, mechanisms of transport, mechanisms of change, budgets and historical records of organic deposition. This research led to the production of a book in 2004, co-edited with Rudy Stein, that has since set the benchmark for organic carbon cycling in the Arctic Ocean. Organic carbon is also central to the cycling of almost every other element in the periodic table, but especially so for the redox elements whose release or capture depends critically on organic metabolism and its effect on oxygen or sulphate. Indeed, it is this connectivity that provides the potential to apply redox elements as paleo-proxies. Accordingly, I have also been researching processes that consume organic carbon, the effect of that consumption on the cycling of other elements, and the development of these other elements as windows into carbon metabolism.

For freshwater processing in the ocean, I have focused almost all of my attention on northern oceans and seas where runoff interacts with ice formation & melting with important consequences to ocean stability, convective overturning, shelf-basin exchange, organic carbon production and transport of material. The challenge of having two means by which freshwater is manipulated in the Arctic Ocean (sea ice and runoff) provides an exceptional opportunity for the application of stable isotope composition ($\delta^{18}\text{O}$) of water, which has the capacity to distinguish between runoff and ice melt/freezing. I have applied $\delta^{18}\text{O}$ measurements in the Arctic Ocean and Hudson Bay specifically to work out freshwater pathways and residence times over the shelves and to determine processes affecting stratification and water storage in both these locations. Along the way, I developed isotopic records in seasonal landfast ice as a proxy for winter oceanographic processes over shelves. Recently, the $\delta^{18}\text{O}$ work has been conducted in the context of understanding organic carbon processing in ice-covered waters, and the prospects for the control of light penetration into the ocean shifting to coloured organic matter (C-DOM) with loss of sea ice due to warming.

Finally, I have studied a wide range of contaminants (organochlorines, radionuclides, hydrocarbons, metals including mercury, ethoxylates) in west coast and Arctic waters. Much of the work has been aimed at revealing large-scale transport processes or investigating generic

processes that conspire to focus and concentrate contaminants in special places that put ecosystems at risk. These processes include physical phenomena, like the air-water exchange over the Bering Sea that 'chromatographs' certain pesticides and thereby decides whether these contaminants enter the Arctic in the atmosphere within days, or take perhaps a decade to get there via ocean currents. These processes also include biological phenomena like biomagnification or migration which, in the case of west-coast salmon, result in the mass transfer of PCBs out of the upper Pacific Ocean and into salmon nursery lakes. This latter process surprisingly circumvents all of the physical pathways normally considered to dominate large scale transport of semi-volatile contaminants.

Through the conduct of system science, as outlined above, I have become recognized for thinking about environmental systems at the large scale and for making connections between disciplines, which has resulted in frequent invitations on committees or to develop and/or lead assessments for contaminants and organic carbon. In these assessments, I have focussed mostly on physical and biogeochemical processes that provide the bottom-up underpinning for larger biota like fish or whales. Rather than thinking about contaminants as 'toxic chemicals', I have tended to apply them as elegant and varied tracers of environmental processes and pathways. These pathways have inevitably led me to my most recent research which has been to couple contaminant and organic carbon cycles and thus project some of the consequences that climate change will have on contaminant exposure and vulnerability in ecosystems. Similarly, I have shown that climate variability cannot be neglected when interpreting complex contaminant time series (e.g., persistent organic pollutants in seals or whales, or sediment core records of Hg). The work that I initiated on interactions between contaminants and climate change in 2003 has now become a major thematic focus for many ongoing national and international studies.

Although I have expended most of my energy studying the Arctic, I have not neglected my west-coast neighbourhood. Accordingly, I have worked my way through a series of studies to determine contaminant pathways and budgets in the Strait of Georgia, and the sources and processes affecting organic carbon. I've also examined connections between the Pacific Ocean, the west coast of North America and interior lakes in the context of contaminant loadings, relying heavily on lake sediment core records. In my work, I have applied a wide range of techniques and tools including sediment coring and dating, watermass analysis, particle flux into sediment traps, multivariate statistical analyses and box modeling.

I have directed/led multidisciplinary environmental programs: NOGAP B.6 (Beaufort Oceanography; 1986-1992); Arctic Environmental Strategy, Northern Contaminants Program (Long Range Transport to the Canada Basin; 1991- present); Greenplan Toxic Chemicals Program (Strait of Georgia Assessment Project; 1993-continuing); Fraser River Action Plan (Long-range transport of contaminants to the Fraser Basin; 1993-continuing), ArcticNet Themes 1&3 (2003-present) and supervised, co-supervised or served on committees for many graduate students.

The research has been conducted in collaboration with over 250 scientists from a wide variety of disciplines as recognized by co-authorship on publications. Among these collaborators are included some of the very best: physical oceanography (K. Aagaard, E. Carmack, H. Loeng); marine geochemistry (A. Chen, E.P. Jones, K.K. Liu, P. Schlosser, J.N. Smith, L.G. Anderson, M. Whitticar); atmospheric chemistry (L. Barrie, J. Pacyna; W. Schroeder; J. Fyfe); limnology and terrestrial geochemistry (J. Smol; J. Blais, B. Finney, D. McGuire, M.S.V. Douglas); contaminants (D.C.G. Muir; S. Eisenreich, T. Bidleman; J. Dachs; T. Harner; K.C. Jones; J.W. Readman); organic geochemistry (R. Stein, M. Goni, M. Yunker, L. Snowdon, R. Harvey; L. Guo; T. Eglinton); sediment geochemistry (E. Crecelius, C. Gobeil, T.F. Pedersen, B. Sundby); geology (B. Bornhold, A.S. Naidu, S. Solomon) and modeling (K. Denman; D. Mackay; A. Omstedt; F. Wania; F. Saucier).

SUMMARY OF ACCOMPLISHMENTS

Publication of ~160 papers in the journal literature, 30 papers in refereed proceedings/book chapters, over 50 technical/data reports and one co-edited book (The Organic Carbon Cycle in the Arctic Ocean, Stein & Macdonald). Co-authored or authored work has been cited over 4700 times (h index = 37). Participation in over 50 field trips, 29 chief scientist, 20 to the Arctic Ocean using departmental vessels, icebreakers and ice-capable aircraft.

MAJOR AWARDS

Elected a Fellow of the American Geophysical Union (2010).

Elected a 'Fellow International' of The Explorers Club (2007).

Miroslaw Romanowski Medal of the Royal Society of Canada (2005)

Fellow of the Royal Society of Canada (FRSC) (2004)

Head of the Public Service Prize co-recipient (2001)

President's Prize of the Canadian Meteorological and Oceanographic Society (2000)

Fellow of the Chemical Institute of Canada (FCIC) (1989)

MINOR AWARDS AND DISTINCTIONS

DFO Distinction Award "In recognition of developing stable isotopes as a method to track where fish have been caught", team leader, 2010.

DFO Prix d'Excellence, co-recipient, 2008.

DFO Distinction Award "In recognition of dedication, commitment and outstanding scientific contribution related national and international climate change research" (2007).

Elected to Faculty Member of the Faculty of 1000 Biology for the "Ecosystem Ecology" Section(2007).

Best Paper award for articles published in Science of the Total Environment during 2004 and 2005

Biographed in the Canadian Who's Who (2005)

Biographed by the American Biographical Institute (2005)

Deputy Minister's Prix d'Excellence (2004)

Assistant Deputy Minister's Commendation (2003)

Vancouver Island Section Award for Outstanding Contributions to Chemistry (1997)

Biographed in American Men and Women in Science (19th Edition) (1995)

Canadian Coast Guard Commissioner's Commendation (1994)

United States Coast Guard Arctic Service Medal (1994)

RECENT APPOINTMENTS AND COMMITTEES

Chair of the Canadian National Committee for SCOR (CNC-SCOR) for 2009-2011.

Canadian IPY Science Review Committee – co Chair.

Ocean-Atmosphere-Ice-Interaction Science Steering Committee. (a component of the National Science Foundation (US) Arctic System Science (ARCSS) program (cf. Codispoti et al., 2001). (2001-2004)

Polar Research Board (United States) of The National Academies (2001-04)

Canadian Arctic Shelf Exchange Study (CASES) science steering committee. (2000-present)

Canadian IPY Steering Committee: Comprises a Canadian team to put forward Canada's International Polar Year science plan.

Continental Margins Task Team: Comprises an international team with the task to assess the contribution of continental margins and seas to CO₂ sequestration and horizontal flux of carbon, nitrogen and phosphorus across the ocean-continental margin boundaries (cf. Liu et al., 2000). My particular role is to lead the assessment of the Arctic Margins.

Canadian National Committee member for the Scientific Committee on Oceanic Research (CNC/SCOR) (2003-2007); (Chair for 2009-)

Committee on A Science Plan for the North Pacific Research Board (NPRB: 2002-2005).

Member of the Editorial Boards for *The Science of the Total Environment*, *Environmental Reviews* and the *Water Pollution Research Journal of Canada*

Guest Editor for a special edition of *Marine Environmental Research* volume 66 (Benthic processes, organic carbon cycling and contaminants in the Strait of Georgia, Canada), 2008

Guest Editor for *The Science of the Total Environment*, 2000 (254(2-3)) and 2005 (Contaminant Pathways)

Adjunct Professor at University of Victoria (CEOR), University of Manitoba (Department of Environment and Geography), and professor invite à l'Institut National de la Recherche Scientifique (Québec).

Current Projects and Funding

Metro Vancouver Monitoring Programme, \$150,000/year, 2008-2012

ArcticNet Theme 3, Co-PI with Stern, \$158,000/year, 2008-2011

Organic carbon flux and change in Canada's marginal seas, Co-PI with Gobeil, \$150,000/year, 2008-2010.

PCBs in Arctic Ocean Water, co-PI with Stern, \$27,000, 2008-09.

PUBLICATIONS (R.W. Macdonald)

JOURNAL ARTICLES

Grant, P.B.C., Johannessen, S.C., Macdonald, R.W., Yunker, M.B., Sanborn, M., Shaw, P., Dangerfield, N., Wright, C., Ross, P.S., 2011. Stuck in the mud: divergent depth-related marine sediment PCB and PBDE profiles explained by BDE-209. *Environmental Toxicology and Chemistry* accepted subject to revision.

Pučko, M., Stern, G.A., Macdonald, R.W., Barber, D.G., Rosenberg, B., 2011. The influence of the atmosphere-snow-ice-ocean interactions on the levels of hexachlorocyclohexanes (HCHs) in the Arctic cryosphere. *Journal of Geophysical Research* in press.

Kuzyk, Z.A., Macdonald, R.W., Stern, G.A. and Gobeil, C., 2011. Inferences about the modern organic carbon cycle from diagenesis of redox-sensitive elements in Hudson Bay. *Journal of Marine Systems*, in press.

Miller, L.A., Papakyriakou, T.N., Collins, R.E., Deming, J.W., Ehn, J., Macdonald, R.W., Mucci, A., Owens, O., Raudsepp, M. and Sutherland, N., 2011. Carbon dynamics in Sea Ice: A Winter Flux Time Series. *Journal of Geophysical Research*, 116: C02028 (doi:10.1029/2009JC006058).

Guo, L., Cai, Y., Belzile, C. and Macdonald, R.W., 2011. Sources and export fluxes of organic and inorganic carbon and nutrient species from the seasonally ice covered Yukon River. *Biogeochemistry*, in press.

McClelland, J.W., R.M. Holmes, K.H. Dunton and R.W. Macdonald, 2011. The Arctic Ocean estuary, *Estuaries and Coasts*, 2011 (doi:10.1007/s12237-010-9357-3).

Torres, M.E., Zima, D., Falkner, K.K., Macdonald, R.W., O'Brien, M.C., Schöne, B.R. and Siferd, T., 2011. Hydrographic changes in Nares Strait (Canadian Arctic Archipelago) in recent decades based on $\delta^{18}\text{O}$ profiles in bivalve shells. *Arctic*, in press.

2011

Pučko, M., Stern, G.A., Macdonald, R.W. and Barber, D.G., 2010. α - and γ -hexachlorocyclohexane (HCH) measurements in the brine fraction of sea ice in the Canadian High Arctic using a sump-hole technique, *Environmental Science and Technology*, 44:9258-9264 (doi:10.1021/es102275b).

Beaudin, L., Johannessen, S.C. and Macdonald, R.W., 2010. Coupling laser ablation and atomic fluorescence spectrophotometry: an example using mercury analysis of small sections of fish scales. *Analytical Chemistry*, 82:8785-8788 (doi: 10.1021/ac1021387).

McGuire, A.D., Macdonald, R.W., Schuur, E.A.G., Harden, J.W., Hayes, D.J., Christensen, T.R. and Heimann, M., 2010. The carbon budget of the northern cryosphere region *Current Opinion in Environmental Sustainability* 2: 231-236 (doi: 10.1016/j.cosust.2010.05.003).

Wang, F., Macdonald, R.W., Stern, G.A. and Outridge, P.M., 2010. When noise becomes the signal: Chemical contamination of aquatic ecosystems under a changing climate. *Marine Pollution Bulletin*, 60: 1633-1635.

Hare, A.A., G.A. Stern, Z.A. Kuzyk, R.W. Macdonald, S.C. Johannessen and F. Wang, 2010. Natural and anthropogenic mercury distribution in marine sediments from Hudson Bay, Canada, *Environmental Science and Technology*, 44(15):5805-5811 (doi:10.1021/es100724y).

Kuzyk, Z.A., R.W. Macdonald, S.C. Johannessen and G.A. Stern, 2010. Biogeochemical controls on PCB deposition in Hudson Bay, *Environmental Science and Technology* 44(9): 3280-3285 (doi:10.1021/es903832t).

Pospelova, V., S. Esenkulova, S.C. Johannessen, M.C.O'Brien, R.W. Macdonald, 2010. Organic-walled dinoflagellate cyst production, composition and flux from 1996 to 1998 in the central Strait of Georgia (BC, Canada): a sediment trap study, *Marine Micropaleontology*, 75(1-4): 17-37.

Macdonald, R.W. and Loseto, L.L., 2010. Are Arctic Ocean ecosystems exceptionally vulnerable to global emissions of mercury? A call for emphasized research on methylation and the consequences of climate change. *Environmental Chemistry*, 7:133-139 (doi:10.1071/EN09127).

Pućko, M., Stern, G.A., Barber, D.G., Macdonald, R.W. and Rosenberg, B., 2010. The International Polar Year (IPY) Circumpolar Flaw Lead (CFL) System Study: the importance of brine processes for α - and β -hexachlorocyclohexane (HCH) accumulation/rejection in the sea ice. *Atmosphere-Ocean*, 48(4):244-262. (doi:10.3137/OC318.2010).

Kuzyk, Z.A., Macdonald, R.W., Tremblay, J.-É. and Stern, G.A., 2010. Elemental and stable isotopic constraints on river influence and patterns of nitrogen cycling and biological productivity in Hudson Bay. *Continental Shelf Research* 30(2):163-176 (10.1016/j.csr.2009.10.014).

Carrie, J., Stern, G.A., Sanei, H., Macdonald, R.W., Outridge, P. and Wang, F., 2010. Increasing contaminant burdens in an Arctic fish, burbot (*Lota lota*), in a warming climate. *Environmental Science and Technology*, 44(1):316-322 (10.1021/es902582y).

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Brimble, S.K., Foster, K.L., Mallory, M.L., Macdonald, R.W., Smol, J.P. and Blais, J.M., 2009. High Arctic ponds receiving bio-transported nutrients from a nearby seabird colony are also subject to potentially toxic loadings of As, Cd and Zn. *Environmental Toxicology and Chemistry*, 28(11):2426-2433.

Lavoie, D., Denman, K. L., and Macdonald, R. W., 2009. Effects of future climate change on primary productivity and export fluxes in the Beaufort Sea. *Journal of Geophysical Research*, 115, C04018 (doi:10.1029/2009JC005493).

Yunker, M.B., Macdonald, R.W. and Snowdon, L.R., 2009. Glacial to post-glacial transformation of organic input pathways in Arctic Ocean basins. *Global Biogeochemical Cycles*, 23, GB4016, (doi:10.1029/2009GB003503).

Belicka, L.L., Macdonald, R.W. and Harvey, H.R., 2009. Trace element and molecular markers of organic carbon dynamics along a shelf-basin continuum in sediments of the western Arctic Ocean. *Marine Chemistry*, 115:72-85 (doi: 10.1016/j.marchem.2009.06.007).

Irvine, J.R., R.W. Macdonald, R. J. Brown, L. Godbout, J. D. Reist, E. C. Carmack, Beyond BASIS (Bering-Aleutian Salmon International Surveys) - salmon in the Arctic. *North Pacific Anadromous Fish Commission Bulletin* **2009**, 5, 39-50.

Johannessen, S.C. and R.W. Macdonald, 2009. Effects of local and global change on an inland sea: the Strait of Georgia, British Columbia, *Climate Research*, 40:1-21 (doi: 10.3354/cr00819).

Kuzyk, Z. A., R. W. Macdonald, S. C. Johannessen, C. Gobeil, and G. A. Stern. 2009. Towards a sediment and organic carbon budget for Hudson Bay. *Marine Geology*, 264:190-208 (doi: 10.1016/j.margeo.2009.05.006).

Granskog, M. A., R. W. Macdonald, Z. Z. A. Kuzyk, S. Senneville, C. Mundy, D. G. Barber, G. A. Stern, and F. Saucier (2009), Coastal conduit in southwestern Hudson Bay (Canada) in summer: Rapid transit of freshwater and significant loss of colored dissolved organic matter, *Journal of Geophysical Research* 114, C08012, doi:10.1029/2009JC005270.

Smith, J. N., K. Lee, C. Gobeil, and R.W. Macdonald. 2009. Natural rates of sediment containment of PAH, PCB and metal inventories in Sydney Harbour, Nova Scotia. *Science of the Total Environment*, 407:4858-4869 (doi:10.1016/j.scitotenv.2009.05.029).

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- Macdonald, R.W., Wang, F., Stern, G.A. and P. Outridge, 2008. Mercury in the Arctic: are we overlooking the ocean? *Integrated Environmental Assessment and Management*, 5(1): 6-8.
- Michelutti, N., B.E. Keatley, S. Brimble, J.M. Blais, H. Liu, M. S.V. Douglas, M.L. Mallory, R.W. Macdonald, J.P. Smol, 2008. Seabird-driven shifts in Arctic pond ecosystems, *Proceedings of the Royal Society B: Biological Sciences*, 276:591-596 (doi:10.1098/rspb.2008.1103).
- Macdonald, R.W., Wang, F., Stern, G.A. and Outridge, P.M., 2008. The overlooked role of the ocean in mercury cycling in the Arctic. *Marine Pollution Bulletin*, 56:63-65 (doi:10.1016/j.marpolbul.2008.09.003).
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- Johannessen, S.C., G. Potentier, C. A. Wright, D. Masson, and R.W. Macdonald. 2008. Water column organic carbon in a Pacific marginal sea (Strait of Georgia, Canada). *Marine Environmental Research*, 66:S49-S61 (10.1016/j.marenvres.2008.07.008).
- Burd, B., R.W. Macdonald, S.C. Johannessen and A. van Roodselaar, 2008. Responses of subtidal benthos of the Strait of Georgia to ambient sediment conditions and natural and anthropogenic depositions, *Marine Environmental Research*, 66:S62 (doi:10.1016/j.marenvres.2008.08.009).
- Macdonald, R.W., Johannessen, S.C., Gobeil, C., Wright, C.A., Burd, B., van Roodselaar, A. and Pedersen, T.F., 2008. Sediment redox tracers in Strait of Georgia sediments – can they inform us of the loadings of organic carbon from municipal wastewater? *Marine Environmental Research*, 66:S112-S120 (doi:10.1016/j.marenvres.2008.08.001).
- Burd, B., Macdonald, R.W., van Roodselaar, A. and Wright, C.A., 2008. *Axinopsida serricata* shell encrustation as a geochemical indicator of organic enrichment conditions in sediments in the southern Strait of Georgia, British Columbia, Canada. *Marine Environmental Research*, 66:S101-S111 (doi:10.1016/j.marenvres.2008.08.008).
- Johannessen, S.C., R.W. Macdonald, C.A. Wright, B. Burd, D.P. Shaw and A. van Roodselaar, 2008. Joined by geochemistry, divided by history: PCBs and PBDEs in Strait of Georgia sediments *Marine Environmental Research*, 66:S112-S120 (doi:10.1016/j.marenvres.2008.03.003).
- Ross, P.S., Couillard, C.M., Ikonomou, M.G., Johannessen, S.C., Lebeuf, M., Macdonald, R.W., Tomy, G., 2008. Large and growing environmental reservoirs of deca-BDE present an emerging health risk for fish and marine mammals. *Marine Pollution Bulletin*, 58:7-10 (doi:10.1016/j.marpolbul.2008.09.002).
- Hare, A., Stern, G.A., Macdonald, R.W., Kuzyk, Z.A. and Wang, F., 2008. Contemporary and pre-industrial mass budgets of mercury in the Hudson Bay marine system: The role of lateral sediment recycling transport. *Science of the Total Environment*, 406:190-204 (doi:10.1016/j.scitotenv.2008.07.033).
- Kuzyk ZA, Goni MA, Stern GA, Macdonald RW, 2008. Sources, pathways and sinks of particulate organic matter in Hudson Bay: evidence from lignin distributions. *Marine Chemistry*, 112:215-229 (10.1016/j.marchem.2008.08.001).
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Outridge, P.M., R.W. Macdonald, F. Wang, G.A. Stern and A.P. Dastoor, 2008. A mass-balance inventory of mercury in the Arctic Ocean, *Environmental Chemistry*, 5, 89-111 (doi:10.1071/EN08002).(cover article).

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Couillard, CM, RW Macdonald, SC Courtenay and V P Palace, 2008. Interactions between toxic chemicals and other environmental factors affecting the risk of impacts on aquatic organisms: A review with a Canadian perspective – Interactions affecting exposure, *Environmental Reviews*, 16, 1-17 (doi:10.1139/A07-007).

Couillard CM, Courtenay SC, Macdonald RW, 2008. Interactions between toxic chemicals and other environmental factors affecting the risk of impacts on aquatic organisms: A review with a Canadian perspective - Interactions affecting vulnerability. *Environmental Reviews*, 16:19-44 (doi:10.1139/A07-008).

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Hickie BE, Ross PS, Macdonald RW, Ford JKB, 2007. Killer whales (*Orcinus orca*) face protracted health risks associated with lifetime exposure to PCBs. *Environmental Science and Technology* 41(18), 6613-6619 (doi:10.1021/es0702519).

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Blais JM, Macdonald RW, Mackay D, Webster E, Harvey C, Smol JP., 2007. Biologically mediated transport of contaminants to aquatic systems. *Environmental Science and Technology*, 41(4), 1075-1084 (critical review), doi:10.1021/es061314a.

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1976

CRUISES AND FIELD-WORK EXPERIENCE

2009 Strait of Georgia on the Vector to service moorings and collect water and sediments. Chief Scientist (Oct 31- Nov 3).

2008 Amundsen Gulf, Beaufort Sea. Chief Scientist for Leg 6a (Jan 31-Feb 21, 2008) for the CFL project aboard the CCGS Amundsen.

2007 Strait of Georgia on the Vector to collect water samples and sediment cores (November 27 – December 1).

2007 Cape Vera, Devon Island – sampling for biovector transport in the Arctic (Ottawa U collaboration), July 4-29, 2007.

2005 Cruise to the Canadian Arctic Archipelago and Hudson Bay (CCGS Amundsen) as part of ArcticNet, September 15-October 1, 2005.

2003 Cruise to Nares Strait, USCGS Healy, July 19-August 19.

2003 BC lakes sediment coring and contaminant cycling measurements in Meziadin Lake, BC.

2002 BC lakes sediment coring for records of contaminants in Shuswap, Moose, Bowron and Quesnel Lakes.

2001 BC lakes sediment coring for records of contaminants in North and East Barriere Lakes, and Frazer Lake (anadromous fish transport study in collaboration with Jules Blais, Ottawa U).

1998 SHEBA recovery section, CCGS *Louis S. St Laurent*, September 1998, CTD, water sampling for changes in the Canada Basin, mooring recovery and deployment (Chief Scientist).

1995 Garrow Lake, May 5-May11, CTD, water and ice sampling for thermohaline work and tailings transport (with P. Erikson and A. Etier).

1995 Fraser Estuary, Feb 7-8, Collecting sediment cores out of McDonald Slough and Gunnerson Slough (with D. Paton and J. Luternauer).

1994 Kitimat Cruise, Vector, Oct 17-22, collecting sediment cores out of Jesse Lake.

1994 Arctic Ocean Section, July 24-Sept 10; Louis S. St. Laurent, Contaminants program.

1994 Fraser Drainage lake coring, Moose Lake, Stuart Lake, Kamloops Lake, June 7-13.

1993 Fraser Drainage lake coring, Vector cruise to the Strait of Georgia Dump Site (3 days); Vector cruise to Kitimat (1 week) to collect cores.

1993 CCGS Henry Larsen Joint Canadian Russian Oceanographic Expedition to the Beaufort Sea, the Chukchi Sea, and the Eastern Siberian Sea; 4 week cruise to make geochemical and contaminant measurements on water, sediments and biota. Included participants from BIO, Scripps and the Russian Ministry of Nature Conservancy.

1992 CCGS Henry Larsen; 3 week cruise in the Beaufort Sea (chief scientist). The cruise involved recovery of 9 moorings and redeployment of 5 of them. We completed another year at the time series deep station in the Canada Basin sampling for chemistry, including the organochlorines

1992 Ice-based field work (April - May), out of PCSP Tuktoyaktuk, using fixed and rotary wing support aircraft and snowmobiles. Objectives included oceanographic sampling, ice sampling, sampling for contaminants and deployment and recovery of moorings (Chief Scientist).

1991 CCGS Henry Larsen; 4-week cruise to the Southern Beaufort Sea, on a ship-of-opportunity, ice-breaker (Chief Scientist). (Deep Arctic mooring, chemical and physical sampling over the Mackenzie shelf and at a deep Arctic basin climate station, sediment pore water studies, organochlorine measurements).

1991 Field work (April - May) on the ice, based out of Tuktoyaktuk and using fixed and rotary wing

support aircraft. Objectives included oceanographic sampling, ice sampling, sampling for contaminants and deployment of moorings (Chief Scientist).

1990 CCGS Henry Larsen; 4-week cruise to the Southern Beaufort Sea, on a ship-of-opportunity, ice-breaker (Chief Scientist). (Deep Arctic mooring, chemical and physical sampling over the Mackenzie and Banks Island shelves and at a deep Arctic basin climate station, sediment pore water studies).

1989 CCGS Sir John Franklin; 2-week cruise to the Southern Beaufort Sea on a ship-of-opportunity, ice-breaker (Chief Scientist). (Chemical and physical sampling over the Mackenzie shelf and at a deep Arctic basin climate station).

1987 CSS John P. Tully; 6 week cruise to the Southern Beaufort Sea to do physical, chemical and biological sampling (total scientific party of 31), (Chief Scientist).

1987 Field work (3 excursions) on the ice, based out of Tuktoyaktuk and using fixed and rotary wing support aircraft. Objectives included oceanographic sampling and deployment of moorings (Chief Scientist).

1987 CSS Vector; 1-week cruise to run instrument intercomparisons and shakedown (Chief Scientist).

1986 Ivik; 1-week cruise to the southern Beaufort Sea to deploy and recover moorings, and carry out oceanographic sampling on shelf-wide transects (Chief Scientist).

1986 Minuk; 1-week, ice-based Arctic field work around Minuk (Esso artificial island) to recover moorings and sample (Scientist).

1985 MEEE; 4 week experiment run at Xiamen in China to develop enclosure technology for the Chinese (Scientist).

1984 CSS John P. Tully; 2-week coastal cruise to Alice Arm to collect cores, sediments and seismic data (Scientist).

1983 CSS Vector; 2-week coastal cruise to Alice Arm to moor traps and collect oceanographic data (Chief Scientist).

1982 CSS Vector; two 2-week coastal cruises to Alice Arm to moor traps and collect oceanographic data (Chief Scientist).

1981 CSS Vector; 2-week, interdisciplinary cruise to Kitimat Fjord Systto collect cores, seismic data, moor equipment and collect oceanographic data (Chief Scientist).

1981 Bell Jar Experiment; 7-week field trip working in Kiel fjord (Federal Republic of Germany) as part of the Canada-Germany cooperative program.

1981 CSS Richardson; collecting cores and sidescan data from Strait of Georgia and Ballenas Basin (Chief Scientist).

1979 RV Poseidon; 3-week cruise to the Baltic as part of a Canada-Germany cooperative program.

1979 RV T. Thompson collecting samples in Saanich Inlet to develop methods for Chromium analysis.

1979 MV Sea Lion; 2-week cruise to Kitimat Fjord System to collect oceanographic data (work contracted to Seakand I acted as departmental representative).

1978 CSS Parizeau; 1-week cruise to Alberni Inlet to collect sediments and oceanographic data (Chief Scientist).

1978 CSS Parizeau; 1-week cruise to Strait of Georgia to collect nutrient data and cores (Chief Scientist)

1977 MV Pandora II; 4-week ship-of-opportunity cruise to Amundsen Gulf (Beaufort Sea) to collect oceanographic data and samples (scientist).

1977 CSS Parizeau; 1-week cruise to Alberni Inlet to make ocean dumping related measurements for dissolved oxygen, and to collect box cores.

1977 CSS Parizeau; 2-week cruise to Kitimat Fjord systto collect oceanographic data in support of

proposed pipe-line terminal studies (Chief Scientist)

1977 CSS Vector; 1-week cruise to Howe Sound to collect samples in support of the ocean dumping program (Chief Scientist).

1976 Submersible Pisces from MV Pandora II; 3-day work in Saanich Inlet to perform liquid chlorine release experiments at various depths (Chief Scientist).

1976 CSS Vector; 1-week cruise to Saanich Inlet to collect box cores and oceanographic data (Chief Scientist).

1976 CSS Vector; 1-week cruise to Howe Sound to collect samples related to Hg pollution (Chief Scientist)

1975 MV Sea Lion; 2-week cruise to Strait of Georgia to perform an ocean dumping experiment at the Point Grey Ocean Dumping Site (Chief Scientist).

1975 MV Pandora II; 4-week cruise to the Beaufort Sea to collect and analyze water samples for low-molecular-weight hydrocarbons (scientist)

1974 MV Theta; 4-week cruise to the Beaufort Sea to collect and analyze water samples for low-molecular-weight hydrocarbons (scientist)