The Hudson Bay System Study (BaySys): Theme 3 of ArcticNet

Theme Leader
Dr. D.G. Barber

Theme Coordinator
Jay Anderson
Project 3.1 investigates the impacts of freshwater quality and quantity on marine processes within Hudson Bay.

What are the implications of these processes on human health, social wellbeing, and development of management policies for Hudson Bay?
Theme 3 - Hudson Bay

Seven core projects:

3.1 - ocean-sea ice-atmosphere (Barber)
3.2 - watershed (Papakyriakou)
3.3 - marine resources (Gosselin)
3.4 - contaminants (Stern)
3.5 - health (Ayotte, Chan)
3.6 - people (Oakes, Riewe)
3.7 - Labrador Fiords (Reimer, Biasutti)
Theme 3 - Hudson Bay

- Geographic Focus
  - Hudson Bay, Foxe Basin and Hudson Strait
  - Freshwater-marine coupling
  - Communities in Western Hudson Bay
  - Paleo-contemporary-predictive
Tale of the Tape

- Numerous oral and poster presentations
- 39 peer-reviewed publications
- 5 books/compendiums
- 6 Post Doctoral Students
- 45 Graduate Students
- 12 High School Students (11 in the north)
Project 3.1 – Ocean-Ice-Atmosphere

To provide detailed observations of the coupling across the ocean – sea ice – atmosphere (OSA) interface of the Hudson Bay marine system for the investigation of physical-biological coupling and development of numerical process models (project 4.1 - modeling).

Team: Barber (PL), Ingram, Gratton, Yackel, Prinsenberg, Carmack, Hanesiak, Papkyriakou, Wadhams (UK), Minnett (USA), Carsey (USA), Drinkwater (Denmark)
Hudson Bay

Nelson Estuary

Churchill Estuary

Pierre Radisson 2006
Amundsen 2005/2007

Estuarine processes 2005-2006

winter-spring breakup 2005-07
Activities:

• Churchill:
  – ice camp – spring 2005/autumn and spring 2006

• Nelson River
  – 18 seasonal moorings in estuary with Manitoba Hydro partner (2005-06)
  – field sampling, summers 2005-07

• Hudson Bay
  – sampling on three icebreaker voyages (2005-07)
  – 11 moorings with 36 sensors (summer 2005-07)
  – historical study through satellite remote sensing
  – community monitoring program at Sanikiluaq through winter (2005-07)
Manitoba Hydro 2006 mooring locations in the Nelson estuary. Colours indicating bathymetry change at 5 m isobath intervals. The bathymetric map was prepared from data collected as a part of the project.
Major findings:

• HSNBA river runoff is confined to a narrow band on the western shore, but wide 200-km-wide zone on eastern shore (Granskog et al. 2007)
• sea-ice melt contributes twice as much freshwater input to upper mixed layer in southern HSNBA as in the northwest, supporting remote-sensing studies (Hochheim et al., 2007)
• sea ice no longer forms in the Nelson estuary in winter because of large hydro-regulated freshwater flows
• high freshwater fluxes to the Bay due to precipitation and flow regulation in winter are affecting ice-ocean coupling as the water spreads under the ice
• sea-ice ridges (stamuki) are important in retaining freshwater under landfast sea ice. Timing of breakup is important to physical-biological coupling (Kuzyk et al, 2007).
• the opening date of the sailing season to Churchill has advanced 3 weeks since 1970 (Tivy et al., 2007)
Project 3.2
Watershed and Bay Coupling

An assessment of the impacts of climate change on the watershed processes in the Hudson Bay Lowlands and their downstream effects (particularly those associated with freshwater and carbon) on Hudson Bay.

Watershed

Estuary

Team: T. Papakyriakou (PL), R. Bello, J. Hanesiak, P. Lafleur, D. Lobb, W. Pollard, K. Snelgrove, M. Tenuta, K. Young
Activities

- **Terrestrial/Aquatic Systems:**
  - field sampling (2004-07)
    - Nutrient/water cycling
    - Microclimatology

- **Watershed Hydrology:**
  - Churchill & Deer Rivers (06-07)
    - Discharge and load

- **Watershed Hydrology:**
  - Churchill & Deer Rivers (06-07)
    - Discharge and load
Major findings:

- Carbon budget of Hudson Bay during the ice-free season (Else et al. 2007a, b)
- HB is a source of atmospheric CO2 in Aug. and Sept., but reverts to a sink in Oct.
- A positive flux of 0.93 GtC was estimated during the ice-free season
- Stark contrast to most Arctic or sub-Arctic continental shelf seas, where usually strong absorption of CO2 is observed
Major findings:

- Plant habitat and moisture status dictates CO2, CH4 and N2O patterns of production & consumption (Bello et al., in prep; Churchill et al. \textit{in prep})

- C-budget in tundra ponds (40% of landscape) appears to benthically-driven (Bello et al., \textit{in prep})

- Key Hydrologic Processes:
  - Lichen and moss species have extremely large rainfall interception storage capacities (Gade et al., \textit{in prep})
  - Tundra ponds are key agents in the routing of water through the aquatic network and into the Bay (Yee et al., \textit{in prep})
Hydrologic Characterization and Modelling ...
Project 3.3 – Marine Resources

To assess how climate-induced variability and change in sea temperature, sea-ice cover dynamics and the timing and intensity of river freshet affect marine biological productivity, fish dynamics and marine mammals in coastal Hudson Bay.

Team: Gosselin (PL), Ferguson, Fortier, Gagné, Hammill, Larouche, Michel, Poulin, Price, Simard and Tremblay
Activities:

- 2004
  - MERICA Expedition
- 2005
  - Sea Ice Camp (Button Bay)
  - ArcticNet Amundsen Expedition
  - MERICA Expedition
- 2006
  - MERICA Expedition
Most of HB is characterized by low phytoplankton biomass with small seasonal cycle. Inter-annual variability was largest near the coasts, showing the strong link to variation in run-off.
The distribution of nutrients is highly heterogeneous and the spatial patterns differed among nutrients. Concentrations of nitrate were highest in the west. Silicate was lowest in the northern wedge, which showed the largest phosphate concentrations.

Nitrate inventories provide a time-integrated estimate of new primary production, which sustains renewable resources and the biological CO$_2$ pump. In this example, new production varies by a factor of 2.
Phytoplankton production ranged from 50 to 400 mg C m\(^{-2}\) d\(^{-1}\) in HB and from 250 to 3500 mg C m\(^{-2}\) d\(^{-1}\) in Hudson Strait & Foxe Basin. Total phytoplankton production was inversely proportional to the strength of stratification in the upper 80 m.
The middle of the Bay has small concentrations of zooplankton and fish. Abundances increase towards Hudson Strait and in coastal areas.
Hydrophones in SE HB have provided insight into whale vocalizations. Similarities have been observed between bowheads in SE HB and the Beaufort. Presence of bowheads in HB has never before been documented.
Project 3.4 - Carbon & contaminant cycling in the coastal environment

- Climate change
- Habitat
- Organic carbon
- Foodwebs
  - Land
  - Air
  - Water
  - Sediment
  - Snow
  - Sea ice
  - Permafrost
Activities:

- 2004
  - Wintertime air-surface exchange (Churchill)
  - Riverine MeHg and THg concentrations in Churchill and Nelson River
  - MERICA Expedition
- 2005
  - Sea Ice Camp (Button Bay)
  - ArcticNet Amundsen Expedition
  - MERICA Expedition
  - Atmospheric Hg measurements in Churchill
- 2006
  - Riverine MeHg and THg concentrations in Churchill and Nelson River
  - Fish collection program at communities
  - Watershed delivery study in Churchill River and coastal watershed
  - Wintertime core sampling
**Objectives of Project 3.4:**

- Processes that drive the high Hg bioaccumulation in the Hudson Bay marine ecosystem;
- Historical, present, and future Hg regimes in the Hudson Bay marine ecosystem;
- Influence of trophic structure on Hg burdens in marine mammals

**Background:** Mercury and methylmercury concentrations in edible tissues (e.g., liver, muscle, muktuk) of marine mammals in the Hudson Bay ecosystem frequently exceeded the Canadian food consumption guideline for MeHg (0.5 µg/g ww for fish; CFIA, 2001)
First Mass Balance Model of Hg in the Hudson Bay Ecosystem

- Hg source is dominated by the atmospheric deposition; rivers contribute a minor proportion.
- Sedimentation is the main process removing Hg from the water column.

Marine sediment core study suggests that Hg deposition to Hudson Bay is regionally specific and has been increasing in some areas over the last century.

* A. Hare et al. in prep
Top trophic-level fish have lower $\delta^{15}N$ in eastern compared to western HB.
Low trophic-level *Calanus sp.* have higher $\delta^{15}N$ in eastern compared to western HB.
Efforts are undertaking to link the abiotic and biotic processes driving the Hg bioaccumulation
Project 3.5 – POPs and Human Health

To obtain comprehensive exposure information and risk assessment parameters on persistent organic pollutants (POPs) for Inuit by the analysis of country foods.

Team: Ayotte (PL), Chan (cL), Dewailly, Egeland, Stern, Young and Weber
Subproject 1. POPS in Traditional Foods and Dietary Exposure (Chan, Stern, Egeland)

- To obtain a comprehensive exposure information and risk assessment parameters on persistent organic pollutants (POPs) for Inuit by the analysis of country foods
• Activities (2004-2007)
  – Analysis of country food samples collected between 1997 and 1999 from NWT and Nunavut – collaboration with EC
  – Measurement of perfluorooctane sulfonate, perfluorinated carboxylates and fluorotelomer unsaturated carboxylic acids – collaboration with Health Canada
  – Analysis of POPs data in wildlife – collaboration with DFO and EC
  – Examine dietary exposure using contaminant data in food samples and food use data collected in 1997-1999
• Subproject 1:
  • Key Messages:
    – Intake of brominated flame retardants and perflurorinated surface treatment chemicals are low and pose minimal risk to human health among Inuit;
    – Updated POPs intake estimate in Kivalik and Baffin was lower than that previously obtained in early 2000
    – More data on caribou and ringed seal meat, narwhal and beluga muktuk, and lake trout are needed for Hg exposure estimate
• Subproject 2. Toxicity of POPs (Ayotte, Chan)
  – To develop biomarkers for early indices of neurotoxicity in human and wildlife populations in the Arctic.
  – To examine the possible relation between exposure to methylmercury and biomarkers of DNA damage and cardiovascular diseases in the Inuit population.
  – To assess the body burden of dioxin-like compounds in the Inuit population.
• **Activities (2004-2007)**
  – Development and validation of analytical methods
  – Studying inter-species differences in neurotoxicological responses to contaminant exposure
  – Studying effects of POPs versus Hg in brain extracts of marine mammals
  – Studying relationship between neurochemical biomarkers and body burden of contaminants in Inuit populations
  – Measuring paraoxonase activity in 900 Inuit adults from Nunavik
  – Measuring dioxin-like compounds using DR-CALUX bioassay in 500 Inuit adults from Nunavik
  – Measuring DNA strand breaks in blood lymphocytes of 300 Inuit adults using the alkaline Comet assay
  – Examining factors influencing biomarkers such as lifestyle habits and body burden of contaminants
• **Subproject 2:**

• **Key Messages:**
  – PBDE has minimal effect on muscarinic receptors (mAChr) and monoamine oxidase (MAO) *in vitro* and *in vivo* using mink as a model
  – MAO in platelets can be used as an indicator for Hg toxicity
  – Observed a negative association between body burden of Hg and MAO activities in platelet samples of Inuit in Nunavik
  – Observed a negative association between body burden of Hg and paraoxonase (PON1) activity in serum samples of Inuit in Nunavik
  – DNA damage measured in lymphocytes of Inuit in Nunavik was not linked to environmental contaminants, rather to alcohol consumption
  – Exposure to dioxin-like compounds is strongly associated to PCB exposure in Inuit from Nunavik
Project 3.6 – People and Environmental Change

By linking Traditional/Local Knowledge with Scientific Knowledge, Project 3.6 aims to better understand the implications and opportunities of environmental change in the Hudson Bay Region.

Team: Oakes, Riewe, Arnold, Clifford-Pena, Chow, Edye-Rowntree, Gilligan, Gislason, Green, Heath, Imrie, Rogala, Sahanatien, Westdal & Young.
Current Research Focus

- Environmental change and off-road transportation in Churchill, MB (Gilligan)
- Beluga co-management; perspectives from Kuujjuarapik & Umiujaq (Gislason)
- Resident perspectives on the Churchill River Diversion (Edye-Rowntree)
- Inuit Perceptions, Comprehension and Awareness of Contaminants in Sanikiluaq (Clifford-Peña)
- Youth Environmental Awareness: Perspectives on Intergenerational Knowledge Transfer on Environmental Change in Churchill, Manitoba (Chow)
- Subsistence fisheries in Churchill, MB (Green)
- Traditional Knowledge on Sea Ice Change in the Belcher Islands: Impacts on Inuit Hunters (Imrie)
- TEK on over-wintering common eiders in the Canadian Arctic (Heath)
- Polar bear habitat selection, movements & sea icescapes in Foxe Basin (Sahanatien)
Recent publications:

A collection of local Churchill residents perspectives and opinions on the impact of Manitoba Hydro’s changes to the Churchill River from 1970 to present.

A collection of refereed manuscripts focusing on the linkages between Traditional/Local Knowledge and Scientific Knowledge regarding climate change in the Arctic.
Project 3.7 – ArcticNet Nunatsiavut
Nuluak

Understanding the Effects of Climate Change and Modernization in a Northern Marine Environment

Team: Ken Reimer and Marina Biasutti-Brown
Focuses on three fiords in northern Labrador

Initiated to address Inuit concerns regarding:
- Climate change in the region
- Human impacts on two of the fiords

Uses a comparative approach to assess the impacts of these combined stressors on the fiords
• Have officially opened an ArcticNet Nunatsiavut Nuluak office in Nain, Labrador

• Inuit and residents of Labrador involved in a meaningful way throughout all phases of the project

• planning, decision-making, implementation, results, communication

• Inuit (Nunatsiavut Government) are the final recipients of all information derived
Activities 2007:
Shore based research from Parks Canada base camp
(Featured on CBC “The National” Big Melt Series)

• Base camp established by Parks Canada and the Nunatsiavut Government
• Base camp is managed by Inuit from Nunatsiavut
• Live in camp with Inuit and their families, learning about the land and Inuit culture
Linkages...

• 3.7 with:
  - Inuit (Nuluak office in Nain, Nunatsiavut government, Sikumiut Environmental Management Ltd., and community consultations, communications)
  - Federal Government (Parks Canada, National Defence, Environment Canada, Fisheries and Oceans)
  - Industry partner (Voisey's Bay Nickel Company)
  - Expanding research links within framework of ArcticNet Nunatsiavut Nuluak (Trevor Bell, Sam Bentley, Reinhard Pienitz, Victoria Edge, Chris Furgal)
Linkages …

- 3.1 & 3.2 - Freshwater-Marine coupling and terrestrial influences on freshwater and marine systems
- 3.1, 3.2 & Manitoba Hydro
- 3.1, 3.2 & 3.3 - Physical-biological coupling in HB
- 3.1, 3.2, 3.3 & 3.4 - Examination of the pathways of contaminants from the watershed to Hudson Bay
- All with 3.6 - Human dimensions of change
- 3.1, 3.2 and 4.1 - Towards the modeling of the physical system
Linkages...

- 3.4 & 4.3 - Establishment of a shore based fish monitoring with the Northern communities
- 3.3, 3.4 & 3.5 - Biological vectors, contaminants and human health
- 3.5 & 4.4 - Risk assessment of POPs related to traditional food consumption in Arctic populations
- 3.6 & 4.2 - Changing exposure to hazards associated with sea-ice use by harvesters in the Canadian Arctic & proposal to explore the impact and opportunities of climate change on tourism in Hudson Bay coastal communities.
- 3.6 & 2.1 - Linking Inuit and biologist knowledge - wintering eider ducks