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ARCTIC SIGnal ™

A busy time for Arctic Science

By Ann McMillan

As 2014 comes to an end, Canadians have much to celebrate. Individually and collectively, a rather small number of people are greatly enhancing our knowledge of our North. Northern prizes of note:

- The *Weston Family Prize for Lifetime Achievement in Northern Research, which* was created in 2011 to honour leading northern researchers who have advanced our knowledge of Canada's northern environment, and significantly contributed to better our understanding of the physical and biological environments, ecosystems, demographics of the North, and evolving climate issues. Dr. Charles Krebs was the winner for 2014.
- The Martin Bergmann Medal for Excellence in Arctic Leadership and Science sponsored by the Canadian Geographical Society. Dr. Donald Forbes was the winner for 2014.
- The Northern Science Award later in this issue.

Our ArcticSIG newsletter, the ARCTICSIGnal has completed its first year of operation. We recognize we have a way to go to deliver on our vision of what a timely, professional-looking newsletter ought to be. Still, we hope you've found it fun and interesting. If you have comments or suggestions or, even better, if you have something to contribute, please do so. Send input to me at mcmillan@storm.ca .

We're aiming for a next issue starting in February. Until then, a very happy and healthy holiday season to all!

In This Issue

WORKING GROUP

The ArcticSIG working group for this issue has been:

- **Martin Taillefer – Chair**
- **Andrew Bell – CMOS Executive Director – SIG Advisor**
- **David Fissel, Ann McMillan, Doug Bancroft, Helen Joseph - Members**

ANOTHER RESOUNDING SUCCESS!

ARCTIC CHANGE 2014 - 8-12 DECEMBER - OTTAWA CONVENTION CENTRE

by Helen C Joseph, HJC Consulting

Over 1400 people recently converged on the Ottawa Shaw Centre for the Arctic Change 2014 conference. This was the annual meeting hosted by the Networks of Centres of Excellence – ArcticNet. However, this year's event was much larger as they welcomed participants from around the globe to Canada's capital from December 8 - 12. The conference participation was truly global and reflects a world-wide scientific interest in the Arctic. There were over 300 non-Canadians in attendance, from 22 countries. Nations such as the United States, Germany, Norway, Russia, France, the United Kingdom, Republic of South Korea and Japan had a presence. In addition, it was truly a pan-Canadian event, as there were over 1,000 Canadians in attendance from all of the provinces and territories. I heard the story that the most common surname amongst the registrants was not Smith, Jones, or even Fortin, rather it was Pokiak! The Pokiak family name is a common one from the region near Inuvik, NWT.

Arctic Change was a resounding success with hundreds of excellent scientific posters, sessions, exhibits and plenary speakers. The week started off with Student Days where the ArcticNet Student Association organized sessions and hands-on workshops. These ranged from workshops dealing with scientific writing, communicating your science, working with media, to panel discussions on collaboration with communities on Arctic research. During this same time, there were several side-meetings occurring amongst other participants. There was a Canada- European Union (EU) workshop where presentations and discussions explored possible areas of priority and collaboration. This meeting was followed on Tuesday with a broader international workshop where research opportunities were explored between Canada and global partners. Initiatives that were stimulating a lot of excitement included the ongoing work and recent call for proposals from Canadian High Arctic Research Station, as well as the EU funded initiative *EU-PolarNet* that is just getting organized. Several countries presented efforts on current and future Arctic S&T priorities, including the U.S.A, Sweden, Norway, Finland, UK, France, Germany, Italy, Korea, and Japan. It was evident that Arctic research and monitoring is truly a global priority.

All of the above workshops and discussions took place BEFORE the Arctic Change conference even started! Arctic Change was launched on Wednesday, December 10 with morning plenary speakers each day followed by concurrent scientific sessions – in fact, over fifty scientific sessions were held during the conference and over 350 scientific posters were displayed. Topics were wide ranging from education, health and well-being in Arctic communities, to permafrost landscapes in transition, to Arctic security, to wildlife co-management, changing commercial and subsistence fisheries. Of interest to the oceanographic and meteorological community were the following sessions (just a sampling amongst the dozens that were held): Arctic Ocean Acidification, Arctic Sea Ice, Changing Arctic Atmospheric Composition, Monitoring Arctic Ecosystems, Physical Forcing and Ecosystem Response in the Pacific Arctic Region, Safe and Sustainable Shipping, and Understanding the Role of Ocean, Sea-Ice and Atmosphere in Arctic Climate. There were several sessions on Arctic data management practices and moving from data to knowledge through data archives and online access tools. In addition, the sessions that examined the Changing Practices towards community engagement in Arctic Research were popular as lessons learned and best practices were shared.

As Canada's two-year chairmanship of the Arctic Council comes to an end in April-May 2015, there were discussions of work achieved during this time and the transitioning of the chairmanship to the USA. The forthcoming American chairmanship will work within the theme of *One Arctic: Shared Opportunities, Challenges and Responsibilities.* The following priorities are emerging within this theme: Addressing Impacts of Climate Change in the Arctic, Stewardship of the Arctic Ocean, and Improving Economic and Living Conditions of Northerners.

After a busy and productive five days, it was evident that our scientific understanding of the Arctic is increasing but that a great deal of research and monitoring needs to continue. The conference provided numerous networking events and opportunities for informal exchange amongst participants. There will no doubt continue to be dialogue and collaborative opportunities emerging over the coming months as a result of the Arctic Change conference.

http://www.arcticnetmeetings.ca/ac2014/

CANADIAN POLAR COMMISSION

2014 NORTHERN SCIENCE AWARD GOES TO…………

DR. ROBIE MACDONALD

The award was presented at a ceremony prior to the Annual Dinner of the Fellows of the Royal Canadian Geographical Society, on November 19th in Ottawa, Ontario.

Left: Robie Macdonald; Right: His Excellency the Right Honourable David Johnston, Governor General of Canada Photo: Matt Zambonin/Canadian Geographic

Citation

Dr. Robie Macdonald, a marine geochemist, has won international respect for his innovative, rigorous, and groundbreaking research using geochemistry to understand earth and ocean processes.

As Head of Marine Environmental Quality at Fisheries and Oceans Canada's Institute of Ocean Sciences, Dr. Macdonald's work spans a gamut that includes trace metals in lake and coastal marine sediments, chemical and biochemical impacts of underwater mine tailing discharges, the fate of pulp-mill derived dioxins and furans in coastal waters and sediments, and Arctic Ocean hydrography.

Through his extensive and ever-expanding body of work, Dr. Macdonald has enriched our knowledge of Beaufort Sea hydrology through his highly novel application of oxygen isotope analyses in sea ice near the Mackenzie Delta; he has improved our understanding of deep-water circulation in the Canada Basin of the Arctic Ocean; and he has mapped (and continues to map) contaminant distributions across the Arctic through measurements of chlorinated organic compounds, PCBs, and metals including mercury.

His key insights into the cycling of contaminants in the Arctic Ocean have been crucial for northerners who rely on fish and marine mammals for food.

Dr. Robie Macdonald is one the world's leading marine geochemists. Honourable, unassuming, and humble, he is held in great esteem by his peers.

How one biogeochemist sees change in the Arctic Ocean

by Robie Macdonald

When I first went naïvely into the Beaufort Sea in 1974 it was a bad ice year. I got what I expected – an ice-choked ocean that prevented our small sealing vessel, the *Theta*, from getting anywhere very far off shore. What I did not anticipate was the dirty Mackenzie River water, squeezed into the near-shore corridor, which resulted in Niskin bottles or Secchi disks disappearing as soon as they entered the water. In 1997, the year of SHEBA, it was possible to go across much of the Canada Basin, but as luck would have it we encountered a storm which put paid to my dream of getting basin-wide sediment cores. This was change, indeed! Subsequently we have witnessed a relentless sequence of years with open water over deep parts of the Canada Basin. If you ask people what single feature most defines the Arctic Ocean they will likely answer "polar bears" or "ice." Physical scientists prefer the latter, public and biologists the former. Undeniably, ice has always been front and centre for this region and it is, after all, what put *HMS Erebus* on the bottom in the southern reaches of the Archipelago in 1846 or thereabouts. Equally undeniably, it is the plight of polar bears presently that most poignantly symbolizes the urgency of change in this part of the world.

My view of the Arctic Ocean derives mostly from looking at the geochemistry of water masses, particulates and sediments. These system components seem to define the Arctic Ocean very differently. So, here's my list:

- Fresh water
- Enormous Shelves
- Large drainage basins
- Ice (somewhat begrudgingly included)

Perhaps to make my point, I have downplayed the role of ice, but the biogeochemical cycles in the Arctic Ocean would not be what they are without the first three bullets above. Ice acts as a modulator to produce change, but ice would have far less to modulate without the first three bullets. Let me explain.

The Arctic Ocean gets more fresh water per unit area than any other ocean in the world. This fresh water comes predominantly from what we call 'meteoric' sources. That is, it has been distilled through evaporation somewhere and thence enters the Arctic Ocean through river inflow, Pacific water inflow or direct precipitation. Although one can demonstrate the importance of meteoric water in the Arctic Ocean by budgetary considerations, the best "CSI" evidence comes from the isotopic lightness of the oxygen held by surface seawater in the Arctic Ocean (specifically, the $^{16}O/^{18}O$ ratio). What, then, does all this fresh water do? It strongly stratifies the ocean thus preventing heat diffusing upward to melt the pack ice, and likewise preventing nutrients from being mixed into the light zone to promote production. At once, the interior Arctic Ocean can remain permanently ice covered, limiting light penetration, and isolated from deeper water, limiting primary production, and thus we see in the interior ocean a shaded organic desert. A direct result is that the basin water receives almost no vertical particle flux from biological production near the surface. Another result is that the formation of sea ice, which injects salt into the surface ocean, is unable to make the surface water dense enough to sink and thereby replace basin water; instead, it makes a polar mixed layer in the top ~50m. But before writing off the sea ice in this way, we need to consider the enormous shelves.

The Arctic Ocean shelves account for almost half the ocean. This ocean sets a second record as the most 'shelfy' of all oceans. Because landfast ice and the moving pack result in a shear zone over interior parts of the shelves, open water is formed in winter, lots of ice is formed, and there is the possibility of making salt (i.e., dense water). This dense water still has the barrier of stratification to deal with, which it solves by entering the interior ocean at relatively shallow depths to form cold haloclines beneath the polar mixed layer. These haloclines, together with the fresh surface layers, stratify the ocean like a licorice allsort, sealing off the water from the Atlantic Ocean, which pervades the abyss. The use of $^{16}O/^{18}O$ is crucial to understand the interaction between ice and meteoric water. Ice, which has a seasonal cycle that removes freshwater from the sea in winter and adds it back in summer, leaves a very different isotopic signature in seawater than does meteoric freshwater. Specifically, you need two tracers (salinity and $^{16}O/^{18}O$) to understand a three component (seawater, meteoric water, ice melt) system. Relying strictly on salinity can seriously mislead you. The view I have come to from

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isotopic studies is that meteoric water does the major work, with sea ice mostly forming an annual cycle, but sometimes contributing salt to the haloclines and thus contributing to a more permanent stratification. The melting of sea ice, as we have been seeing during the past two decades, can contribute extra fresh water, but this is limited by the volume of ice available. Runoff, however, continues perennially and there is some indication that it has been increasing over the past several decades. Slightly. My conclusion is that if we wish to worry about Arctic freshwater processes affecting thermohaline convection in the Atlantic Ocean, we need to think about storage and release of meteoric water more than we need to worry about a relatively small increase in runoff, or an unsustainable sea-ice melt-off.

The large shelves are where biological production can occur. What supports this production? Clearly, upwelling at the shelf edge or at the ice edge is a widely distributed process. But, again, freshwater plays an important role. In the interior ocean, the fresh water tends to accumulate (Beaufort Gyre) and thus stall nutrient return to the surface, but around the margins, the freshwater runoff moves across the shelf, entrains deeper water and thus helps to bring nutrients to the surface. Biogeochemical measurements together with organic carbon budgets suggest to me that freshwater in motion supports biology, stagnant freshwater thwarts it. Perhaps Hudson Bay forms the best example of this: the interior part of the Bay is oligotrophic compared to the margins, which play host to a perennial counter clockwise circulation that transports the runoff out of the system, entraining nutrients along the way. There are many other features of shelves that are important, but in my geochemical view one of the more important ones is the insertion of moderately dense water into the haloclines. This water is tagged not only by $^{16}O/^{18}O$, but by nutrient enrichment and O_2 depletion due to the regeneration of biological detritus at the shelf bottom. Thus it is, that shelves leave their imprint sideways across the wider Arctic Ocean in the structure and composition of the haloclines.

Now, about the drainage basins. Again, the Arctic Ocean sets a record for its relatively large drainage, which supply particulates and organic carbon in addition to all that fresh water. Sediments in the Arctic Ocean reveal in their biomarkers and carbon isotopes (^{14}C, ^{13}C, ^{12}C) a strong component of terrigenous organic carbon. Over half of the organic carbon eventually stored in the Arctic's shelf and basin sediments comes from land! Indeed, sometimes it is difficult to understand what the marine component of the carbon cycle is doing because of the terrigenous mask. Having looked at sediments, particle flux and suspended sediment, I've come to the view that the Arctic has a large primary production engine over the shelves which produces labile carbon, to which is added a mixture of young and very old organic carbon from land. Most of the former gets recycled over the shelves, while much of the latter preserves in sediments. In its inorganic and organic particulate cycles, the Arctic Ocean is again very 'sideways.' Vertical flux in the interior Arctic Ocean is the smallest in the world oceans, and particulates get into the interior from shelves by a variety of sideways processes initiated at the margin, eddies perhaps being one of the more important ones.

So what does change in ice climate do to change biogeochemical cycles? I think it starts on land; the Arctic's permafrost is a point of vulnerability. Thawing leads to erosion and release of ancient particulate carbon, and alteration of soil processes and vegetation that affect younger dissolved carbon. Both of these processes are exported to the Arctic Ocean by rivers, but differently in dissolved and particulate organic components. At the coast, thaw of permafrost together with loss of sea ice add, perhaps enormously, to the supply of organic and inorganic particulates through coastal erosion. Already we are seeing in many parts of the Arctic a rapid retreat of poorly bonded, low topography soils due to open ocean in the autumn, which fosters greater wave activity from storms. These changes will first be seen over the shelves, but will work their way to the interior ocean because of the sideways delivery mechanisms. Change in sea ice will likely alter upwelling and shelf-edge processes alone will not tell us how the Arctic Ocean is changing biogeochemically.

Furthermore, loss of seasonal ice may, counterintuitively, enhance the production of dense water over the shelves, thus more strongly feeding the haloclines. Finally, the rotting of ice in at least some parts of the Arctic Ocean will release algal mats that can descend rapidly into the basins, thus altering the budgets and fluxes of carbon and associated elements (P, N, Si) to the abyss. It is hard to say exactly how all these cycles will play out, but there are clear indications to me that pH, the role this ocean plays in the global CO_2 cycle, and organic forcing of a number of elements whose cycles are controlled by reduction-oxidation processes in sediments will all be affected.

While watching the cover of sea ice change using satellite images and other techniques is crucial, this alone will not tell us how the Arctic Ocean is changing biogeochemically. Because biogeochemical indicators from samples collected within this ocean provide ways to distinguish between different sources (marine, terrigenous) and processes (ice related, vertical flux, horizontal transport), I argue that organized biogeochemical measurements should form a core component of time series. After all, we need to know what is changing before we can say why it is changing, and whether our models mirror reality.

Robie says when a picture was requested: "me getting a sediment core out of a shallow pond on the N side of Devon Island at Cape Vera (taken by Jules Blais). I've used it to illustrate that ship support has become difficult in DFO…. And yes, that water was bloody cold. But I got the core."

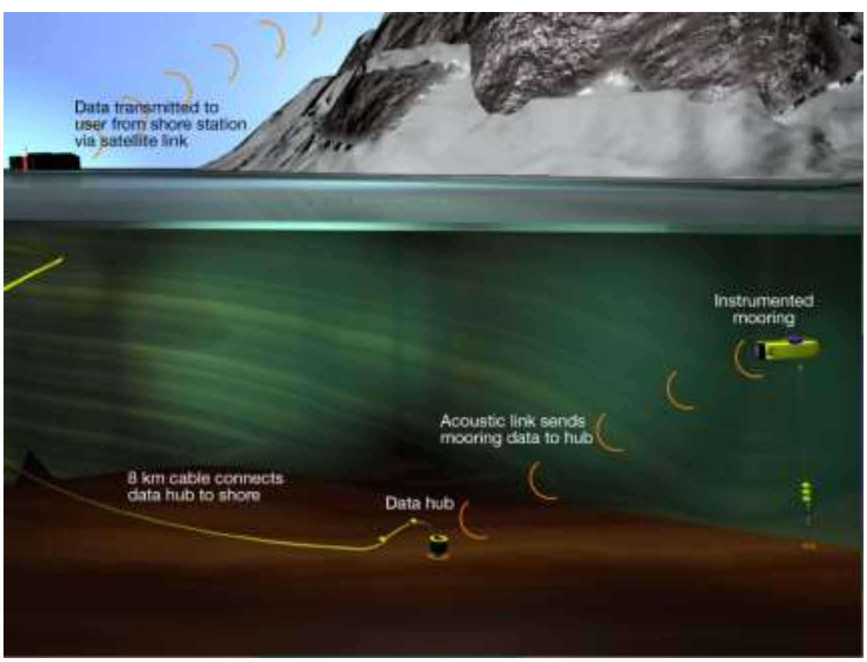
A New Navigational Aid and Ice Forecast Capability with an Arctic Real Time Ocean Observatory

By Jim Hamilton
DFO, Bedford Institute of Oceanography

Collecting oceanographic data in the Arctic has unique challenges because of its remoteness, ship availability and, of course, the ice. But given the magnified impacts of climate change on the Arctic region, it is essential that we have long time series data to track trends in ice, ocean properties, and the biota to better understand and plan for the change. Successful observational programs have provided valuable oceanographic data in key Arctic locations. One example is an array of moorings maintained across the eastern end of the Northwest Passage from 1998 to 2011, which allowed us to quantify the magnitude and variability in Arctic Ocean freshwater export through this principal gateway into the Northwest Atlantic [*Peterson. Hamilton, Prinsenberg, Pettipas 2012, JGR, V117*]. Those data also allowed us to identify strong links between ocean properties, sea ice and plankton on inter-annual time scales [*Hamilton, Collins and Prinsenberg, 2013, JGR, V118*].

Providing oceanographic data in real time adds another level of challenges and operational complexity particularly when trying to do this in the Arctic. But real time ice and ocean information are valuable to Arctic mariners and also for input into ice forecast models. This need has driven the development of our real time ocean observatory off the south coast of Devon Island in the eastern end of the Northwest Passage, which began delivering year round real time data in August, 2011. The observatory uses acoustic modems to pass data from instrumented moorings to a hub at the end of an 8 km long underwater cable. The data pass though the cable to a shore station where a 2-way satellite link transmits the data back to Bedford Institute of Oceanography every 2 hours. At the shore the cable is routed through a pipe to protect it from ice damage. This pipe and the science hut that houses our satellite transmitter are part of the "Northern Watch" infrastructure which colleagues at Defence Research and Development Canada (DRDC-Atlantic) are kind enough to share with us. Their logistical support and that of the Canadian Coast Guard have been essential in allowing this new development to happen.

Located only 30 km to the west of the northern end of the mooring line mentioned above, the relationships seen there hold at our observatory location. Those long time series data demonstrated that freezeup in this area is tightly connected to salinity at 40 m depth in the previous summer. With this knowledge and the real time data from the observatory, we were able to forecast freezeup within 2 days in both 2012 and 2013 with lead times of 4 and 2 weeks respectively [*Hamilton and Pittman, accepted for publication in Atmos-Oc.*]



DFO's ocean observatory in the eastern Northwest Passage.

Last August we visited our observatory to do the required annual servicing, to add a second instrument node for delivery of ice draft data in real time, and to add upgrades to our electronics and communications systems. Those upgrades allow for additional sensor capacity, 2-way remote control of all sensors, and data compression to reduce communications power requirements. With all of the offshore work done we went ashore for the telltale moment of truth; do we see a complete data set arriving at the shore station on the bi-hourly schedule? Communicating with the hub through our 8 km cable with a laptop, we did indeed see our data packets of upper ocean currents, temperature and salinity from 40, 80 and 150m depth, and an ice draft data file all arrive on schedule! But when we reconnected out shore station that handles relaying of data home we encountered a strange communications problem between the shore station and the hub. In spite of efforts that stopped just short of ripping apart personal cell phones and cameras for electronics components that just might solve the problem, we could not sort it out in the little time we had. Those tight schedules, just another challenge of doing field work in the Arctic.

Next summer we will return to Gascoyne Inlet with solutions to try, and every intention of success. Until then all data are being logged at our cable hub, thereby extending the data time series that are so important to improving our knowledge of change at seasonal to inter-annual time scales. This knowledge, combined with a real time data delivery capability, shows promise as a useful ice and ocean forecast tool in the harsh and remote Arctic marine environment.

Project engineer Merle Pittman at the observatory cable landfall.

SAON UPDATE

Sustaining Arctic Observing Networks (SAON) Canada is pleased to release the first issue of the SAON Canada Results Bulletin, which highlights results from monitoring initiatives occurring across the Canadian North, along with their links to policy. This Bulletin was developed in partnership with the Canadian Polar Commission and the Association of Polar Early Career Scientists (APECS) Canada.

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