# ESSAS Poster Session on Arctic-Subarctic Interactions At the 2012 Ocean Sciences Meeting

The Arctic and the Subarctic are intrinsically linked, not only through exchange of water but also in the fluxes and movement of flora and fauna between the two regions. Both regions are experiencing profound changes under present warming and are predicted to be even more highly impacted under future global change. To understand how climate variability and change affect will affect these marine ecosystems, it is essential to understand the role of physical and biological fluxes between the Arctic and Subarctic as well as the mechanisms that link the physical characteristics and biological systems of these ocean areas. At the last ESSAS Open Science Meeting in May 2012, a Workshop was held on Arctic-Subarctic Interactions to bring together the various communities working at the boundary between the two regions to discuss the gaps in our knowledge and what research is needed to fill those gaps. An outcome of the workshop was that a Theme Session should be convened at the 2012 Ocean Sciences Meeting (OSM) in Salt Lake City in February of 2012. The session was to be jointly sponsored by ESSAS and the Arctic-Subarctic Ocean Fluxes (ASOF) program. Ken Drinkwater from ESSAS and Tom Haine from ASOF submitted a proposal for a Theme Session on Arctic-Subarctic Interactions to the OSM and subsequently a poster session was convened at Salt Lake City during 20-24 February. The theme session focused upon the links between the Subarctic and Arctic regions in both the Pacific and the Atlantic, building upon ongoing studies and recent IPY results. Evidence was sought on the role of the cold Arctic outflows on the physical conditions in the Subarctic and their subsequent effects on the biology as well as the influence of the warmer Subarctic inflows on the Arctic basin and shelves. A total of 9 posters were presented and ranged from pure physical oceanography to effects and transport of bacteria and zooplankton. Studies covered both the Atlantic and Pacific connections to the Arctic and included observational and modeling results. The abstracts for the papers, together with the list of authors and their email addresses, are provided below. The authors can be contacted if you would like more information on the specific subject. Although we were disappointed that not more abstracts were submitted, the ESSAS poster session on Wednesday evening was well attended and the posters that were presented were of a high quality, both visually and scientifically.

## SHELF WATER SALINITY VARIABILITY: EASTERN NEWFOUNDLAND TO CAPE HATTERAS, AND POSSIBLE FRESHWATER SOURCES

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Shelf water salinity, temperature, volume, and position of the shelf front along the eastern seaboard of the U.S. and Canada show large inter-annual fluctuations over the last three decades. Fresh water sources responsible for large-scale, shelf-wide spatial and temporal

patterns of salinity variability have not been clearly identified. We seek to understand the role of Labrador Current (LC) transport fluctuations and pathways over and around the Tail of the Grand Banks, and through the Strait of Belle Isle (SBI), along with freshwater inputs from the Gulf of St. Lawrence onto the Canadian and U.S. continental shelves through examination of upstream LC transport variability and changes in St. Lawrence River freshwater discharge using a proxy quantity (RIVSUM). Minimum mean surface salinity and large annual sea surface salinity fluctuations on the eastern Scotian Shelf strongly suggest a Gulf of St. Lawrence fresh water source. However, on inter-annual time scales, lagged correlations between RIVSUM and eastern Scotian Shelf sea surface salinity, account for only 12% of salinity variance, implying a greater importance for input of low salinity Labrador Shelf water through SBI.

## A COMPARISON OF ZOOPLANKTON ABUNDANCE AT THREE BERING SEA MOORINGS

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Pathways of zooplankton advection through the Bering Strait may be indicators of bowhead whale activity. Such pathways can be identified using Acoustic Doppler Current Profiler (ADCP) data to find areas of high diel vertical migration (DVM), characteristic of bowhead prey zooplankton species, such as the euphausiids *Thysanoessa raschii* and *T. inermis*. It is proposed that the euphausiid population of the Beaufort Sea originates in the Bering Sea, but it is unclear where in the Bering Sea these zooplankton originate. Data from three ADCP moorings in the northern Bering Sea are analyzed to identify areas and timing of highest acoustic backscatter, as well as to compare relative amplitude between two years (2008-2009). There was higher zooplankton abundance and greater variation in DVM at the westernmost mooring during both years. Zooplankton abundance was greatest for all locations from mid-September to early January during 2008, with the increase in abundance occurring one month earlier during 2009. In aggregate, these results suggest the western Bering Sea as a more probable route for zooplankton advection, and serve to validate recent modeling efforts.

## THE ARCTIC OCEAN IN SUMMER: A NEAR-SYNOPTIC INVERSE MODEL OF BOUNDARY FLUXES OF HEAT, FRESHWATER AND NUTRIENTS

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The first near-synoptic estimates of Arctic Ocean and sea ice net fluxes of heat, freshwater and nutrients are calculated using an inverse model. Hydrographic measurements from four gateways (Bering, Davis and Fram Straits, and the Barents Sea Opening) completely enclose the ocean, and were made in the same 32-day period in Summer 2005. The inverse model is

based on density layers calculated from temperature and salinity profiles, and includes representations of Fram Strait sea ice export and of interior Arctic Ocean vertical fluxes. The inverse model is initialized with velocity profiles measured by ship-mounted and moored instruments. Volume and salinity transport constraints are applied. In summer 2005 the transport-weighted mean properties, are, for water entering the Arctic: potential temperature 3.29˚C, salinity 34.62 and potential density (sigma0) 27.56 kg/m3; for water leaving the Arctic, including sea ice: 0.72˚C, 34.20 and 27.42 kg/m3, respectively. The Arctic in summer freshens and cools the inflows by 0.42 in salinity and 2.56 ˚C, and decreases density by 0.13 kg/m3. The volume transport into the Arctic of waters above ~1000 m depth is 8.3 Sv (1 Sv = 106 m3/s), the export (similarly) is 8.3 Sv; the net surface freshwater input is 180±46 mSv. Non-stationary components of the freshwater budget are estimated separately. The net heat flux (including sea ice) is 182±26 TW. Net nutrient exports are 0.2 (nitrate), 0.9 (phosphate) and 14.9 (silicate) kmol/s.

## READING BETWEEN THE LINES: BIVALVE GROWTH RATE AND ISOTOPIC VARIABILITY ACROSS THE BARENTS SEA POLAR FRONT

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We examined shell growth patterns and tissue stable isotopic composition (δ13C, δ15N) of the Hairy cockle (*Clinocardium ciliatum*) in the northwest Barents Sea to evaluate the influence of different water masses and the polar front on growth rates and food supply over seasonal to decadal scales. Overall shell growth rates were highest in Atlantic water, intermediate in Arctic water, and lowest at the Polar Front. Temporal patterns of ontogenetically-adjusted growth (SGI) were correlated with regional climatic oscillation modes and local sea ice, with the highest growth associated with colder periods with more sea ice. Stable isotope values of tissues progressively increased from Arctic to Atlantic waters, with the latter enriched in δ13C by up to 2.1‰ and δ15N by 1.5‰. There were distinct seasonal and water mass variations in stable isotopic and C:N values, indicating both spatial and temporal variability in food supplies to the bivalves in this region. Integrating results of sclerochronological and stable isotopic analyses results provides added insight on differences in food sources and pelagic-benthic coupling between water masses of the Barents Sea on small spatial scales.

## XCTD HYDROGRAPHIC MEASUREMENT DURING UNCLOS 2011 CRUISE

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The importance of the Arctic Ocean circulation to the global thermohaline circulation has been recognized, but the circulation scheme of the Arctic Ocean is still highly uncertain. In August-September 2011, CCGS Louis S. St-Laurent had a cruise from the Canadian Arctic coast toward the Lomonosov Ridge in tandem with USCGC Healy (UNCLOS 2011 cruise).

During UNCLOS 2011 cruise, 78 hydrographic profiles were collected by eXpendable Conductivity, Temperature, and Depth data acquisition and processing equipments (XCTD). Using these data, we examined distribution, characteristics, and mixing processes of these water masses in order to understand the circulation scheme of the Arctic Ocean. One of the interesting points is that Pacific-origin water masses can be found at the north of the Chukchi Rise in September 2011, although no signal of these water masses was there in 2008 and 2009. According to the previous publications, Beaufort Gyre circulation was intensified in a recent couple of years. However, the XCTD data in 2011 might suggest a relaxation of the intensified circulation and a change of water mass distributions around the Mendeleyev Ridge and the north-western Canada Basin. Interannual variability is discussed in the context of changes in atmospheric circulation pattern and recent sea ice reduction.

## SEASONAL CIRCULATION IN THE CANADIAN ARCTIC ARCHIPELAGO

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The Canadian Arctic Archipelago (CAA) is a complex network of straits and basins connecting the Arctic Ocean and the Atlantic Ocean. The aim of our study is to understand the variability in volume transport passing through the CAA. A configuration of the Nucleus for European Modeling of the Ocean (NEMO) ocean/sea ice model is set up to study the seasonal and inter-annual circulation for the Canadian Arctic Archipelago. The seasonal circulation pattern in the Canadian Arctic is well simulated. In general, the modeled volume transport through western Lancaster Sound agrees well with observations. We use model sensitivity experiment to demonstrate that from January to May the ice stress on the ocean reduces the volume transport through Parry Channel. The seasonal variation of wind forcing also has strong impact on the seasonal variation of volume transport through Parry Channel.

## ON THE ROLE OF ADVECTION ON THE ECOLOGY OF ARCTIC AND SUBARCTIC SEAS

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A brief review of water mass advection between the Arctic and Subarctic regions and the effects on their ecology will be presented. The influence of Arctic outflows through Fram Strait, the Barents Sea and the Canadian Archipelago on the subarctic regions and the inflow of Pacific waters through the Bering Strait and of Atlantic Waters through the Fram Strait and the Barents Sea on the Arctic will be discussed. In addition to describing temperature and freshwater fluxes between the two regions, the role of advection of sea ice from the Arctic and its associated flora and fauna to the Subarctic will be mentioned. Nutrient fluxes and influences on stratification will be presented in terms of their effects on phytoplankton production. Advection of water masses also transports zooplankton communities between the two regions, as well as some ichthyoplankton. Brief mention will be made on the role of fronts between outflowing Arctic Water and inflowing Pacific and Atlantic Water. Possible future changes in advective fluxes between the Arctic and Subarctic will be highlighted along with their possible effects on the marine ecosystem.

## CARBON FLUX THROUGH THE MICROBIAL FOOD WEB IN THE BARENTS SEA

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Microbial food web dynamics and trophic links to mesozooplankton were examined in the Barents Sea in May and August-September 2010 and June 2011. A set of shipboard grazing experiments was conducted at sea temperatures ranging from -1.8$^{o}$C to 8.6$^{o}$C. Across the shelf microzooplankton herbivory was a significant factor controlling phytoplankton and often exceeded that by pelagic copepods. Its rates increased with temperature, but the maximum relative impact on primary production occurred within the Polar Front (>100% daily). In turn, the predominant calanoid species *Calanus finmarchicus* and *C. glacialis* derived ca. 40% their daily carbon ration from microzooplankton in the ice-covered Arctic waters east of Svalbard and the warmer Atlantic-influenced waters off the Finnmark coast, respectively. These data indicate that the microbial food web plays a critical role in this productive Arctic shelf ecosystem.

## FRESHWATER PATHWAYS IN THE ARCTIC AND SUB-POLAR NORTH ATLANTIC

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Significant fluxes of low salinity water pass from the Pacific Ocean into the Arctic Ocean, and after mixing with other freshwater sources in the Arctic, are transported into the North Atlantic. These pathways and the associated fluxes can have a significant impact on physical, chemical and biological ocean properties and potentially can impact aspects of the large scale circulation and climate. Specific details on how Pacific Water travels from Bering Strait to the Canadian Arctic Archipelago are uncertain. As well, the fate of the freshwater (of Pacific and other origin) that passes through the Canadian Arctic Archipelago is uncertain. In particular how does this freshwater leave the boundary current system and where is it taken up into the Atlantic Ocean. We examine these questions using several eddy-permitting regional configurations of the NEMO coupled ocean/sea-ice numerical model. As well as examining hydrographic properties and fluxes, we use the lagrangian float tool Ariane to examine the freshwater pathways and their variability.