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Carbon Cycling and pH regulation on the Scotian Shelf, NW Atlantic

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This presentation intends to describe the biogeochemical context for ocean acidification studies on the Scotian Shelf. The seasonality of the dominant processes, regulating surface ocean CO_2 conditions, including pH, will be assessed as well as cross-shelf transports of CO_2, acidity and nutrient, the latter ones exerting the "subsurface control" of CO_2 air-sea fluxes and surface pH.

Methods summary:
The seasonal variability of inorganic carbon in the surface waters of the Scotian Shelf region of the Canadian northwestern Atlantic Ocean was assessed using hourly measurements of the partial pressure of CO_2 (pCO_2), and hydrographic variables obtained by an autonomous moored instrument (44.3°N and 63.3°W). These measurements were complemented by seasonal shipboard sampling of dissolved inorganic carbon (DIC), total alkalinity (TA), and pCO_2, at the mooring site, and over the larger spatial scale.

The Scotian Shelf is a 700 km long section of the continental shelf off Nova Scotia. Bounded by the Laurentian Channel to the northeast, and by the Northeast Channel and the Gulf of Maine to the southwest, it varies in width from 120 to 240 km covering roughly 120,000 km2 with an average depth of 90 m . Convective mixin in winter time and coastal upwelling and the associated favorable wind conditions on the Scotian Shelf have long been recognized. Strong winds of speeds greater than 10 m s[U+2011]1, blowing to the northeast, and persisting for several days force relatively cold, saline, water toward the surface, displacing the warmer, fresher water offshore. Upwelling events have frequently been observed in the region in winter, and modeling studies have reproduced these observed events. Furthermore, these events may play a role in initiating and sustaining the spring phytoplankton bloom by displacing nutrient-depleted surface water and bring nutrient-rich waters up to the surface.

Biological processes were found to be the dominant control on mixed-layer DIC, with the delivery of carbon-rich subsurface waters also playing an important role. The region acts as a net source of CO_2 to the atmosphere at the annual scale, with a reversal of this trend occurring only during the diatom dominated spring phytoplankton bloom, when a pronounced undersaturation of the surface waters is reached for a short period. During that time, the pH is at its annual maximum (pH≈8.15), while the Aragonite saturation state reaches its minimum just before the onset of the spring bloom in late March. After of the spring bloom period, the competing effects of temperature and biology influence surface pCO_2 in roughly equal magnitude. During that time carbon fixation is driven by the smaller phytoplankton size classes, which can grow in warmer, nutrient poor conditions. In the Scotian Shelf region the summertime population these numerically abundant small cells accounts for approximately 10-20% of annual carbon uptake. The regional mean surface water pH is roughly 7.8 in April and increases to greater than 8.0 in September; subsurface pH is approximately 7.6 throughout the region and indicates a seasonal decrease due to the respiration of organic matter at depth. The surface aragonite saturation state increases from less than 2.0 to values as high as 3.2 between April and September; the region as a whole exhibits relatively low saturation states, however values approaching 1.0 were only observed in the Cabot Strait at depths below roughly 100m. Subsurface onshore gradients of CO_2 and nutrient species yield onshore carbon, nutrient and hydrogen ion (H+) fluxes in subsurface waters, which in turn regulate surface pH and fuel the CO_2 outgassing from the Scotian Shelf.