***4.3 Nutrients (Fig. 5)***

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Samples for nitrate, nitrite, soluble reactive phosphorus (SRP) and silicate determination were collected into 20 ml polyethylene flasks, immediately poisoned with mercuric chloride (Kirkwood, 1992), and stored for subsequent laboratory analysis according to Raimbault et al. (1990) and Aminot and Kerouel (2007). Ammonium concentrations (40 ml collected into 60 ml polycarbonate tubes) were measured onboard using the sensitive method of Holmes et al. (1999) having a detection limit of 5 nmoles.l-1.

Samples for organic matter determination were collected into 50-ml Glass Schott bottles, immediately acidified with 100 µl of 0.5N H2SO4 and stored in the dark at 5°C. DOC, DON and DOP were determined at laboratory using the wet-oxidation procedure according to Raimbault et al. (1999).

Nitrate levels were always very low in surface, with concentration generally lower than 10 nmoles.l-1, except in the Mackenzie plume. It is interesting to note that nitrate was never entirely depleted and some traces (5 to 10 nmoles.l-1) were always detectable in surface waters.

Ammonium distribution showed the same pattern. Even if concentrations were very low (generally < 30 nmoles.l-1), this nutrient, like nitrate, was always detected, suggesting that in situ sources of nitrate and ammonium exists offshore, certainly due to biological processes.

Phosphate concentrations showed an opposite distribution. Despite nitrogen depletion, surface waters were always phosphate repleted. Highest concentrations, around 0.5 µmoles.l-1, were observed far from the Mackenzie mouth, revealing a clear west to east gradient.

The silicate distribution was similar than this of nitrate. But Surface waters were always silicate-repleted with concentrations largely above the detection limit (> 4 µmoles.l-1).

Impact of the Mackenzie River is clear, close to the coast for inorganic nutrients and farther offshore for dissolved organic nutrients. A quarter of the estimated annual nutrient supply by the Mackenzie River occurred during July-August. The supply of DON was 8 times larger than that of nitrate-N. By contrast, the amount of DOP supplied was only 2.5 times higher than the amount of phosphate (Tremblay et al., 2014). The Mackenzie River enriched the western Canadian Beaufort Shelf with inorganic and organic N, potentially supporting most of primary production, but not with phosphate nor ammonium. Large deliveries of N relative to P by rivers relax coastal communities from N limitation, allowing them to tap into the excess P originating from the Pacific Ocean. Then, river inputs locally rectified the strong regional deficit of inorganic N, i.e. negative N\* (Tremblay et al., 2014).

***4.7.1 Phytoplankton primary production (Fig. 10)***

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At each productivity station, rates of carbon fixation (primary production) were determined using a 13C isotopic technique (Raimbault and Garcia, 2008). For this purpose, three 580-mL samples were collected at minimum sun elevation or before sunrise at 6-7 depths between the surface and the depth where irradiance was 0.3% of the surface value, and poured into acid-cleaned polycarbonate flasks.

Incubations were carried out immediately following tracer addition in an on-deck incubator. This consisted of 6-7 opaque boxes, each with associated neutral and blue screens, allowing around 50%, 25%, 15%, 8%, 4%, 1% and 0.3% light penetration. At 5 stations, incubations were also performed *in situ* on a drifting rig with incubation bottled positioned at the same depth where samples for on-deck incubations were collected. After 24 hours samples were filtered through precombusted (450°C) Whatman GF/F filters (25-mm diameter). After filtration, filters were placed into 2-mL glass tubes, dried for 24h in a 60°C oven and stored dry until laboratory analysis. These filters were used to determine the final 13C enrichment ratio in the particulate organic matter on an Integra-CN mass spectrometer. Filtrates were poisoned with HgCl2 and stored to estimate ammonium regeneration and nitrification rates. The isotopic enrichment of particulate organic matter and dissolved NH4+ and NO3- at the end of incubations was used to calculate net C and N uptake and the recycling of NH4+ and NO3- (Raimbault et al., 2004).

Daily rates of primary production at the surface where generally very low across the survey area, ranging from 0.1 µg C l-1 d-1 offshore to a maximum 545 µg C l-1 d-1 in Kugmallit Bay associated with the Mackenzie River discharge (Tremblay etal., 2014). Ammonification and nitrification followed the same coastal-offshore pattern with rates driving most, if not all, of the NH4+ and NO3- consumption in the surface layer.

Primary production was generally maximum at surface but high rates were often observed at depth in the nitracline layer associated with a chlorophyll maximum. The range of uptake rates of ammonium in surface generally overlapped with the range of nitrate uptake rates. Nitrate uptake below the surface amounted to 40–60% of total nitrogen uptake , a proportion approximatively twice greater than at the surface (Ardyna et al., 2017)

Nitrification and ammonium regeneration were detectable over the whole water column ranging from 2 to 20 nmoles.l-1.24h-1. Highest rates were generally located at the base of the euphotic zone, leading to the formation of subsurface ammonium and nitrite maximum layers.

Surface communities and especially accumulation of large cells thrived mostly on regenerative NH4+ and their reliance on NO3- increased with depth to reach a maximum in the subsurface chlorophyll maximum, where substantial levels of primary production occurred (Ardyna et al., 2017). This is consistent with Ortega-Retuerta et al. (2012) who reported elevated bacterial abundance and bacterial production rates in association with photoammonification of riverine organic matter (Le Fouest et al., 2012).

Nitrification accounted for a variable and sometimes large share of the NO3- demand, consistent with the persistence of trace amounts of NO3- at the surface. Collectively, the data indicate that the coastal Beaufort Sea is an active regenerative system during summer, probably fueled by large pools of organic matter brought by rivers. Consequently, new production was very low and often close to zero in the 0-40m layer. But high nitrate uptake rates can be observed at depth (Station 135), often associated with high primary production located in the chlorophyll maximum layer being the place of significant new production.

Collectively, the data indicate that the coastal Beaufort Sea is an active regenerative system during summer, probably fueled by large pools of organic matter brought by rivers (Le fouest,2012). The impact of the Mackenzie River on shelf productivity during summer is moderate and associated mostly with localized nutrient recycling in the nearshore estuarine transition zone (Tremblay et al., 2014).

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