# PRIMARY PRODUCTION UNDER THE ICE IN THE NORTHERN CHUKCHI SEA: NUTRIENT UTILIZATION AND PRODUCTION OF DISSOLVED AND PARTICULATE ORGANIC CARBON AND NITROGEN

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A major question for shelf/basin exchanges is to determine to what extent and by what mechanisms organic material produced on the shelves is exported to the central basins of the Arctic Ocean. To address this question for the western arctic we are assembling data on the distribution of inorganic nutrients and dissolved and particulate organic material in the Chukchi Sea and in portions of the Canadian Basin. Data sets that will be made available through the archives include the 1994 Arctic Ocean Section, 1996 cruises in the Chukchi Sea (June and September), and the SHEBA ice drift (1997-1998).

Results from the 1994 Arctic Ocean Section (Wheeler et al. 1997) for late July - August showed that inorganic nutrients were elevated at the bottom of the water column over the shelf and presumably contribute to the elevated nutrients in the halocline water across the slope. Organic carbon and nitrogen are distributed differently. Maximum values are in surface water (the upper 50 m) and there is no evidence that organic material is exported into the halocline layers. Forty to fifty percent of the total organic carbon and nitrogen is present in the particulate fraction over the shelf and these particulate concentrations exceed concentrations in basin water by a factor of 2-3. Conversely, DOC and DON are 3-4 times higher over the slope and basin compared to the shelf. The low levels of both POC and DOC in the northern Chukchi Sea and in the nutrient rich halocline in late July argue against a large export of dissolved organic carbon from the Chukchi Sea into the central Arctic during the summer. Much of the shelf derived carbon appears to be remineralized and then exported as dissolved inorganic carbon (Sambrotto 1996). In the central Arctic under the ice primary production was significantly higher than suggested by earlier measurements. Annual under the ice production was 15 $gC/m^2$ (Wheeler et al. 1996, Gosselin et al. 1997). About thirty percent of primary production was released as DOC. The major sources of DOC in the central Arctic appear to be in situ production (56%, Gosselin et al. 1997), river run-off (25%) and inputs from the Pacific water (19%).

Results from the 1996 Arctic West cruise in the Chukchi Sea and the SHEBA ice camp suggest that the seasonal production started during late spring/early summer under the ice cap (Table 1). As nitrate is depleted, particulate and dissolved organic carbon accumulate (Fig. 1). New production estimated from nitrate depletion is 72 gC/m2/y, while total production is estimated as $\geq$ 144 gC/m2/y. One third of new production remains in the water column as organic carbon (30% in the particulate fraction and 70% in the dissolved fraction). This suggests that two thirds of the produced carbon is exported (to the sediment or by advection) consumed by pelagic zooplankton, or respired. As nitrate is utilized, nitrogen accumulates in the water column as DON, ammonium and PON (Table 2). Between 2-32% of the depleted nitrate is exported (to the sediment or by advection). These results suggest that significant primary production takes place under the ice during spring in the northern Chukchi Sea. The organic carbon and nitrogen

produced during this period is likely exported across the shelf/slope into the Canadian or Makarov Basins.

Table 1. Inorganic nutrients and organic carbon and chlorophyll integrated in the water column under the ice over Hanna Shoal in the northern Chukchi Sea (2-23 June 1996).

| Station | Distance from ice edge (km) | $NO_3^-$ | $PO_4^{3-}$ | $Si(OH)_4$ | TOC | Chl |
|---|---|---|---|---|---|---|
| | | (mmol/m$^2$) | | | | (mg/m$^2$) |
| 72°40'N 161°15'W | 277 | 964 | 109 | 2340 | 2732 | 10 |
| 72°41'N 164°42'W | 203 | 798 | 103 | 2120 | 2912 | 129 |
| 71°15'N 163°56'W | 139 | 625 | 72 | 1807 | 3163 | 28 |
| 70°50'N 164°57'W | 111 | 444 | 62 | 1576 | 3922 | 90 |

Table 2. Partitioning of nitrogen in the water column under the ice over Hanna Shoal in the northern Chukchi Sea (2-23 June 1996).

| Station | NO3$^-$ | DON | $NH_4$ | PON | Total N |
|---|---|---|---|---|---|
| 72°40'N 161°15'W | 964 | 428 | 71 | 10 | 1493 |
| 72°41'N 164°42'W | 798 | 370 | 64 | 79 | 1350 |
| 71°15'N 163°56'W | 625 | 712 | 86 | 28 | 1466 |
| 70°50'N 164°57'W | 444 | 407 | 98 | 90 | 1010 |

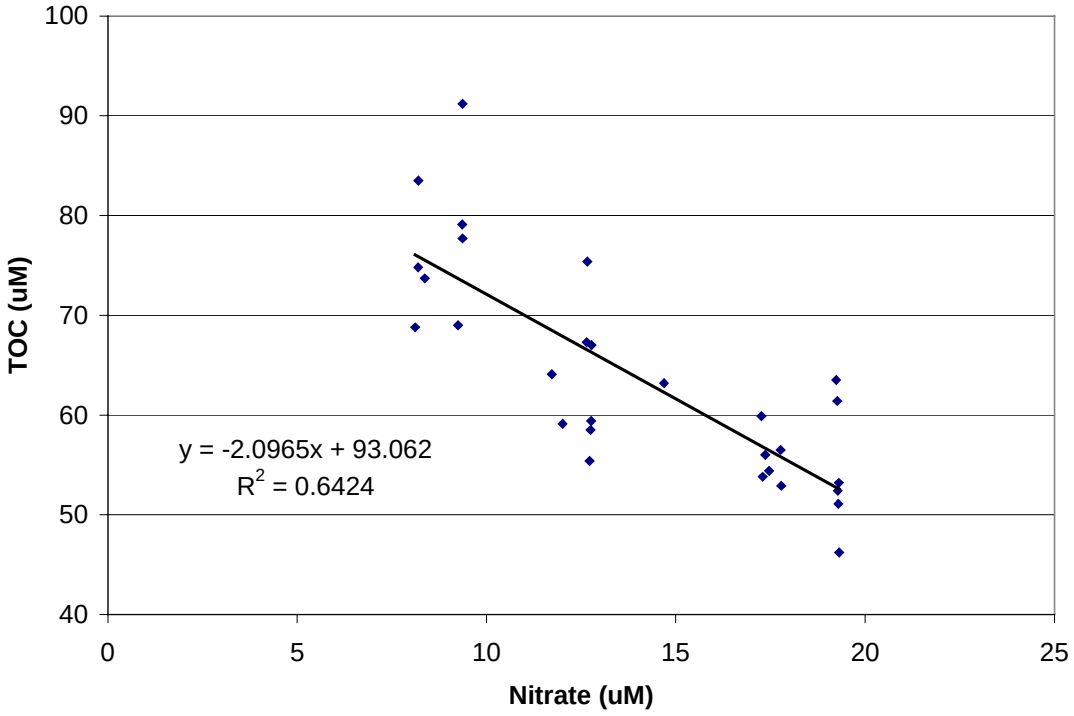


Figure 1. Accumulation of TOC in the water column under the ice in the northern Chukchi Sea as nitrate is depleted 2-23 June 1996.

Taken together these recent studies indicate several sources and pathways of transfer of organic material from the western arctic shelves into the Arctic basins: river inputs of DOC, shelf derived carbon respired in the sediments and released into halocline waters, and shelf derived suspended POC and dissolved DOC advected from the shelf to the basin in the upper layer of the water column. Each of these processes may have a different seasonal periodicity and would be differently affected by changes in ice cover and changes in circulation patterns. In addition to these allochotonous sources of organic carbon, the central Arctic basins have indigenous populations of phytoplankton and zooplankton (Wheeler et al. 1996, Thibault et al. 1999) and significant levels of primary production (Gosselin et al. 1997) and accumulation and release of dissolved and particulate organic carbon (Wheeler et al. 1997). The challenge in pan-Arctic studies is to develop a sufficient data base for quantitative comparison of the various sources and sinks for carbon in the Arctic. Once this is achieved the potential effects of changes in climate and ice cover can be evaluated.

**References**


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