Water structures and circulation along with bio-geochemical processes in the Arctic Ocean suggested with nutrients and oxygen distributions

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Climatological water mass structures were identified in the Arctic Ocean, using the geochemical dataset in the Hydrochemical Atlas of the Arctic Ocean (HAAC). In addition, a geochemically conserved parameter PO_4^* was considered under the following process: when the water column remineralization of organic matter occurs, the content of phosphate increases with decline of dissolved oxygen according to remineralization stoichiometry at the rate of $P:O_2 = 1: -175$ (Anderson and Sarmiento, 1994). The equation is formulated as
$PO_4^* = PO_4 + DO/175 - 1.95$ (μmol/L, Broecker, 1991)
Once the values of PO_4^* are very close to each other, there is high possibility that they have a common origin.
In the upper ocean above 500-m depth, as widely known from various datasets, the Pacific-origin Water (P-Water) is clearly indicated with higher silicate, higher phosphate and lower dissolved oxygen than the Atlantic-origin Water (A-Water). The boundary between the water masses is located along 135˚E-45˚W at the surface and rotates counter-clockwise with depth, confirming the anti-cyclonic circulation of P-Water in the surface layer (0 to 200-m depth), and the cyclonic circulation of A-Water in the subsurface layer (200 to 500-m depth), exchanging between the Arctic and the Atlantic oceans, caused by the water density contrast. Therefore, the HAAC dataset is reliable as a supplier of oceanographic information for a half century.
In the lower ocean below 1500-m depth with the basins separated by the Lomonosov Ridge, dissolved oxygen is lower in the Canadian Basin than the Eurasian Basin. The lower phosphate and higher dissolved oxygen are limited to the vicinity of the Barents Sea and the Fram Strait. Useful information was obtained from PO_4^* (Table below): i.e., the lower-ocean water is maintained by a descending flow along the Siberian continental slope coming from the Atlantic through the Barents Sea, in addition to penetration of the Nordic Seas Deep Water flowing from the Greenland Sea. The former component circulates cyclonically to the Canadian Basin, as shown with PO_4^* =0.65~0.67, along with the high core of PO_4^* =0.86 at 2000m-depth in the southern Canada Basin under the influence of the shelf water. The latter component with PO_4^* =0.72 spreads along the sea floor (3500-m depth) from the Atlantic side to the Pacific side.
The lower-ocean water mass gradually receives nutrients from sinking organic matters, and provides the intermediate-layer water between the upper and the lower oceans. The intermediate water is mostly occupied with A-Water and entrains water from the subsurface portion also, returning toward the Atlantic.
Anderson and Sarmiento, 1994: *Global Biogeochemical Cycles*, **8**, 65-80.
Broecker, 1991: *Oceanography*, **4**, 79-89.
Table: The values of PO_4 and DO taken from the horizontal maps with rounding at 2%. The unit is μmol/L. The values are confirmed with the vertical profiles.

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Location	PO_4	DO	PO_4*
Northern boundary of Barents Sea (200m & 500m)	0.85	310	0.67
Canadian Basin excluding high PO_4 area (2000m) & all (2500m)	1.00	280	0.65
Canada Basin in high PO_4 area (2000m)	1.15	290	0.86
Eurasian Basin (2000m & 2500m)	0.95	300	0.72
Greenland Sea Fram Strait (500m)	0.70	340	0.69
Greenland Sea Fram Strait (2000m)	0.70	310	0.52

