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Title: *Utilizing Chemical Signatures to Study the Arctic Ocean*

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Before 1980 very few investigations of the Arctic Ocean were performed by western scientists, especially regarding its chemical signatures. In 1980 the Swedish Ymer 80 expedition investigated the waters around Svalbard, including full depth profiles of chemical properties across Fram Strait and the southern Nansen Basin. This was also my first experience of the Arctic Ocean. We could trace the high silicate concentration of the halocline, that had been observed at the T-3 ice island (Kinney et al., 1970) and the LOREX ice camp (Moore et al., 1983), along the East Greenland continental margin. The surface waters of the East Greenland Current also showed high relative concentrations of total alkalinity (TA) and calcium with the residual at zero salinity having a 2:1 ratio, a signature of calcium carbonate dissolution. The source of this calcium carbonate could be either sea ice melt or river runoff. During MIZEX 84 I was on board the German R/V Polarstern and here we got the possibility to analyse ice cores, collected by J. Gow, W.B. Tucker, and W.F. Weeks, for TA and calcium. No excess of either could be found in any of the 76 samples from 4 multiyear and 4 first year ice cores. The conclusion was that the excess TA and Ca as observed during YMER 80 was attributed input from river runoff.

During my post doc visit in the laboratory of Peter Jones, the Bedford Institute of Oceanography, Canada, I had the opportunity to evaluate the data collected during the CESAR ice camp. The similar oxygen and nutrient profiles as observed at the T-3 ice island were found here, but now complemented by profiles of total dissolved inorganic carbon (DIC) and TA. The excess of phosphate, nitrate, DIC and deficit in oxygen were found to be very close to the classic RKR ratios, which made us conclude that the signature was a result of mineralization of organic matter on the shelf sediment surface. During a study of the Storfjorden from the Norwegian ship Lance in 1986 the result of organic matter mineralization was observed, with elevated concentrations of nutrient and DIC and low concentrations of oxygen in water that were enriched in salinity by brine addition from sea ice production. The CESAR profiles of TA and DIC, together with data at the Arctic Ocean entrance at Fram Strait collected during Ymer 80 and MIZEX 84, allowed us to make the first assessment of the atmospheric CO_2 uptake into the Arctic Ocean, which equalled around 0.1 Gt C yr^{-1}. This estimate included substantial uncertainties mainly a result of one profile from the whole Arctic Ocean being used. Improved estimates of exchange with both the atmosphere and the surrounding oceans where performed in 1998 utilizing data from several cruises to both the central Arctic Ocean as well as the shelf seas, applying a carbon budget computation based on individual water

masses and regions. This updated estimate resulted in an order of magnitude lower uptake from the atmosphere, or 0.011 ± 0.014 Gt C yr^{-1}.

With the wealth of new data being collected during the 1990th in the central Arctic Ocean the tracing of circulation using chemical property distribution started. Intermediate water circulation was suggested based on the CFC and silicate distribution, the so called "Rudels diagram". Surface water circulation was deduced from nitrate to phosphate relationships. Several approaches where taken to estimate the deep water formation rates using C-14 as well as CFCs to constrain plume models. Deep water formation rates also gave the opportunity to compute the Arctic Ocean anthropogenic carbon sink and inventory. On a global scale these estimates are low, but on a per area scale they are substantially higher than the global mean.

From around the year 2000 the investigations of the Arctic Ocean have changed from a more exploratory phase to a more change phase. This has largely been driven by the substantial decrease in summer sea ice coverage. I will conclude the presentation by some remarks of potential changes in the fluxes of carbon between the atmosphere and ocean.

References

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Moore, R.M., M.G. Lowings, and F.C. Tan, Geochemical profiles in the Central Arctic Ocean: Their relation to freezing and shallow circulation, J . Geophys. Res., 88, 2667-2674, 1983.