

The Transpolar Drift as a Source of Riverine and Shelf-Derived Trace Elements to the Central Arctic Ocean

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Introduction

The supporting information for this paper consists of two main elements: a description of the analytical methods used in generating the data and the data itself (available as a separate Microsoft Excel file).

Text S1. Methods Appendix

The methods for TEIs already published can be found in the papers listed in Table S1 below. For the determination of DIC and TA concentrations, methods are previously published in Ulfsbo et al. (2018) and Woosley et al. (2017). However, the joint description of the two cruises and the uncertainty analysis was not previously discussed. The precision from replicate sample analyses was estimated to be better than $2 \mu\text{mol L}^{-1}$ for both DIC and TA during GN04 (Jones & Ulfsbo, 2017) and better than $2.5 \mu\text{mol L}^{-1}$ and $2 \mu\text{mol L}^{-1}$ for DIC and TA, respectively, during GN01 (Kadko et al., 2016). The accuracy of DIC and TA was determined by routine analyses of Certified Reference Materials (CRM) provided by A.G. Dickson, Scripps Institution of Oceanography, USA. Deep water (> 2000 m) mean concentrations for both cruises at the cross-over station (GN04-101 and GN01-31) agree within the uncertainty of the measurements. Uncertainty propagation for the carbonate system variables was performed according to Orr et al. (2018). Based on input variables from Table 1 of Orr et al. (2018) with two of the carbonate system parameters, the combined relative uncertainty for the third measured parameter was calculated using standard uncertainties in the dissociation constants and total boron to salinity ratio given by Orr et al. (2018). The propagated combined standard uncertainty was $3.3 \mu\text{mol L}^{-1}$, $3.2 \mu\text{mol L}^{-1}$, and 0.012 units for DIC, TA, and pH, respectively.

DOC was determined by high temperature combustion on a Shimadzu TOC-L, as described by Dickson et al. (2007). Consensus Reference Waters were analyzed as a regular check on the quality and reliability of the measurements (Hansell, 2005). The DOC measurements from both cruises (GN01 and GN04) were done in the same lab and were consistent at the crossover stations.

Fluorescent components of chromophoric DOM (CDOM) were measured in situ using two Dr. Haardt fluorometers with backscatter fluorescence sensors that excite at 350-460

nm and emit at 550 nm. The light source and settings in the two sensors were slightly different on the GN01 and GN04 cruises, so the two fluorometers were intercalibrated using a polynomial fit of the data collected at a crossover station to ensure comparability. The correlation coefficient for the polynomial function was $r^2=0.994$. As noted in the Methods section, certain TEI data (dFe, dZn, dCd, dMn; Table S1) are presented as the average of data collected from multiple laboratories and different analytical methods (e.g. Flow Injection Analysis vs. Inductively Coupled Plasma Mass Spectrometry); therefore, the data for these TEIs used in this paper cannot be found on any of the online databases. Please refer to the provided supplementary data file for the average values as well as the original data sources used to create the averages.

There was good agreement between the ^{228}Ra and ^{226}Ra measurements made on the GN01 and GN04 transects. At the crossover station, ^{228}Ra activities measured on GN04 were 14.9 ± 1.0 dpm 100L^{-1} at 10 m and those measured on GN01 were 16.2 ± 0.6 dpm 100L^{-1} and 17.2 ± 0.6 dpm 100L^{-1} at 2 m and 24 m, respectively. The ^{226}Ra activities measured at 10 m on GN04 were 9.1 ± 0.5 dpm 100L^{-1} , while those measured on GN01 were 11.2 ± 0.2 dpm 100L^{-1} and 10.9 ± 0.4 dpm 100L^{-1} at 2 m and 24 m, respectively.

The REE data collected at the crossover station (stations HLY1502-30 and PS94-101) within 14 days compare well especially below 500 m water depth, where they are within 1 pmol L^{-1} for Nd and 0.5 pmol L^{-1} for Er. Given the typical analytical uncertainties of ± 0.4 pmol L^{-1} for Nd and ± 0.2 pmol L^{-1} for Er (GN04), the agreement between the two datasets is excellent. Moreover, both laboratories participated in a small inter-laboratory comparison of dissolved REE in seawater aliquots from 3000 m water depth at SAFE North Pacific station. The results of all four participating labs agreed within 3.3 % RSD for all REE except Ce, Gd, and Lu (Behrens et al., 2016).

The GN01 and GN04 Hg species data were intercalibrated at the crossover station. Total Hg concentrations agreed well for the majority of sampling depths. The tHg and MeHg data have been intercalibrated and validated by the GEOTRACES standards & intercalibration committee.

The GN01 and GN04 expeditions collected and analyzed thorium samples from the crossover station in the Makarov Basin and are well-intercalibrated with the exception of a few outliers, which are likely due to the uncertainty in ^{232}Th blank-corrections in the GN04 dataset. Th analyses were shared among 4 groups: LDEO and U. Minnesota for GN01, AWI (Valk et al., 2019) and LSCE (Gdaniec et al., 2020) for GN04. These 4 groups had participated in the GEOTRACES intercalibration exercise on Th isotopes (R. F. Anderson et al., 2012). A new intercalibration paper based on this Arctic work and focusing in particular on shallow samples is in preparation.

Table S1. References from which data was drawn for use in this TPD synthesis paper or from which methods were used to generate previously unpublished data. Refer to the publication for the sample handling and analytical methods pertaining to the TEI of interest.

TEI	Reference(s)
Hydrography, inorganic nutrients (NO_3^- , PO_4^{3-} , SiO_4)	(Cutter et al., 2014)
$\delta^{18}\text{O}$	(Pasqualini et al., 2017)
Total alkalinity, dissolved inorganic carbon	(Dickson et al., 2007; Kadko, Millero, et al., 2016)
DOC	(Hansell, 2005)
Ra isotopes	(Kipp et al., 2018, 2019; Rutgers van der Loeff et al., 2018)
dBa	(Ho et al., 2019; Jacquet et al., 2005)
POC, bSi, $\delta^{13}\text{C}$ -POC	(Lam et al., 2018)
pFe, pAl, $\text{pmol L}^{-1}\text{n}$, pBa	(Lam et al., 2018; Planquette & Sherrell, 2012)
dFe (GN01 is average of Fitzsimmons, John & Hatta; PS94 is average of Gerringa ICP-MS and FIA analysis)	(Conway et al., 2013; Hatta et al., 2015; Jensen et al., 2019; Middag et al., 2015; Rijkenberg et al., 2014)

dMn (GN01 is average of Fitzsimmons & Hatta)	(Hatta et al., 2015; Jensen et al., 2019)
dCd, dZn (GN01 is average of Fitzsimmons & John)	(Conway et al., 2013; Jensen et al., 2019)
dNi, dCu, dPb	(Conway et al., 2013; Jensen et al., 2019; Middag et al., 2015)
Soluble and colloidal Fe ultrafiltration	(Fitzsimmons & Boyle, 2014; Hatta et al., 2015)
Fe-binding organic ligands	(Slagter et al., 2017)
dAl	(Measures et al., 2015)
dCo, LCo	(Hawco et al., 2016)
$\delta^{56}\text{Fe}$, $\delta^{66}\text{Zn}$, $\delta^{114}\text{Cd}$	(Conway et al., 2013)
dGa	(Ho et al., 2019)
dV	(Whitmore et al., 2019)
Hg species	(Agather et al., 2019; Heimbürger et al., 2015; Lamborg et al., 2012)
dNd, dEr	(Behrens et al., 2016)
^{232}Th	(Anderson et al., 2012)

Data Set S1. All data used in the paper is included in the supplementary Microsoft Excel data file "jgrc15920-sup-data_set_S1.xlsx".