

Netherlands

The Dutch GEOTRACES project aimed to map the distribution of important trace elements and isotopes and investigate the deep sea microbiology in the West Atlantic Ocean. Since the last report to SCOR of 2009/2010 two more Dutch GEOTRACES cruises have been performed together completing the Western Atlantic Transect from 65°N to 50°S, Figure 8.

PELAGIA 64PE321, 11 June through 8 July 2010, Bermuda to Fortaleza (Brazil), chief scientist Dr. Micha Rijkensberg (micha.rijkenberg@nioz.nl).

During leg 2 of the Geotraces cruise a total of 22 full depth stations were conducted with 1 test station, 14 normal stations (1 ultraclean 27 L & 1 normal 25 L hydrocast), 4 superstations (addition of deep in situ pump sampling and samples for Pa/Th) and 3 hyperstations (deep in situ pump sampling, 2 ultra clean & 3 normal hydrocasts).

Trace metal clean sampling was performed using the ultraclean Titan frame with PVDF samplers which was upon recovery immediately placed inside its clean laboratory container (Figure 9), where sub-sampling of a large variety of filtered or unfiltered seawater was done for (shipboard or afterwards) determinations of concentrations of Fe, Mn, Al, Co, Cu, Zn, Ag, Cd, Pt, Pb; physical-chemical speciation of Fe; large volumes for natural isotope systematics of Si, Fe, Zn, Cd, Pb, Nd; major nutrients; $^{14}\text{CO}_2$ and $^{13}\text{CO}_2$. Underway trace metal clean aerosol samples were collected using air filter units. Surface seawater samples for Fe speciation, Pt and Pb isotopes were sampled inside a trace metal clean container from tubing connected to a torpedo towed alongside the ship (Figure 9). The regular Niskin-type samplers and the in situ pumps provided the often required large volumes for natural or anthropogenic (radio)-isotopes systematics of ^{15}N , ^{99}Tc , ^{129}I , ^{137}Cs , ^{210}Pb , ^{210}Po , ^{226}Ra , ^{228}Ra , ^{227}Ac , ^{230}Th , ^{234}Th , ^{238}U , ^{231}Pa , ^{237}Np , $^{239,240}\text{Pu}$ and supporting parameter Dissolved Organic Matter (DOM). Complementary to GEOTRACES, many samples were collected for a transient tracers program comprising DIC, ALK, O_2 , nutrients, CFC's and above mentioned $^{14}\text{CO}_2$ and $^{13}\text{CO}_2$, and for a microbial oceanography program comprising DOC, DON, bacterial and viral abundance, bacterial and archaeal and viral production, ^3H -FISH, ^{14}C -FISH and DNA microbial biodiversity and POC, ^{13}C plus ^{15}N by NanoSims, Nitrification, qPCR. These complementary transient tracers and deep sea microbial oceanography will play a role in unraveling the processes controlling the GEOTRACES variables, and vice-versa.

Two cross over stations were sampled with i) BATS important as a cross over station with various US GEOTRACES cruises, and ii) our hyperstation 36 (lat: 7° 45' 57"N, long -48° 52' 58"W) as a cross-over station with RV Meteor cruise M81/1 (GEOTRACES cruise A11, 4 February until 8 March 2010, chief scientist M. Frank, IFMGEOMAR, Kiel).

An interesting aspect of leg 2 was our encounter with water masses consisting of seawater mixed with Amazon and Orinoco river water, Figure 10.

RRS JAMES COOK JC057, 2 March through 6 April 2011, Punta Arenas (Chile) to Las Palmas (Spain), chief scientist Dr. Micha Rijkensberg (micha.rijkenberg@nioz.nl).

With 18 full depth stations sampled during our last leg 3 including 12 normal-, 2 super- and 4 hyperstations we now completed a transect of 54 stations from 65°N to 50°S, see Figure 8 for cruise track and full West Atlantic Ocean transect. In situ pumps were used in the surface 300 m of the hyperstations and two additional stations. Our hyperstation 6 at -39°58'06" N and -42°29'15" W forms the cross over station with the UK GEOTRACES cruise on the RRS Discovery (chief scientist Gideon Henderson) along 40°S to be completed in December 2011.

On board we had a diverse party of international scientists from Brazil, Germany, France, UK, USA, Austria and the Netherlands. We sampled an even more diverse set of parameters with direct on board measurement of the trace metals Fe, Al, Mn, Co, Zn and Cd, the CO_2 system, nutrients, organic

speciation and size fractionation of Fe, ^{234}Th and bacterial and archaeal production. We also sampled a large set of parameters for the international community including Ag, Pt, Cu, Zn, Hg, Ba, U, Mo, the rare earth elements, the isotopes of Cd, Cr, Ni, Nd (water column and bottom sediments), Pb, Fe, Zn, Si, ^{15}N , $^{13/14}\text{C}$, ^{230}Th , ^{231}Pa , ^{232}Th , ^{18}O , D and other parameters as CFC's and a whole range of parameters to increase our understanding of the deep sea microbiology.

Figure 11 shows as an example silicate concentrations for the full transect of the West Atlantic Ocean.

Planning of Mediterranean Geotraces, Hein de Baar and Micha Rijkenberg attended the Mediterranean Geotraces workshop on 4th to 6th October in Nice, France, to investigate the use of the Dutch Research vessel RV Pelagia for Geotraces transects in the Mediterranean and Black Sea.

Ocean Sciences 2012 conference in Salt Lake City, Utah, USA. Micha Rijkenberg, Rob Middag, Stephanie Owens and Patricia Cámara Mor organize a session on the Ocean Sciences 2012 conference in Salt Lake City with the title: "Advances in the oceanography of Trace Elements and Isotopes in the Atlantic and Polar Oceans" inviting topics on trace elements and isotopes in the Atlantic and polar oceans, including methods, intercalibration, field data and ocean modeling. Relevant topics in other oceans are most welcome as well.

Update on outputs from GEOTRACES activities involving Dutch researchers (July 2010-June 2011):

Meetings

Post cruise meeting Dutch GEOTRACES leg 1 & 2, 17 & 18 January 2011 at the Royal NIOZ, Texel, The Netherlands

Presentations

Klunder, M.B., P. Laan, R. Middag, C-E Thuroczy, L. Gerringa, H.J.W. De Baar. Trace Metals in the Polar Oceans. IPY – Oslo Science Conference, Oslo, Juni 2010.

Middag, R. Dissolved Aluminium and Manganese in the Polar Oceans. Oral presentation at the 2010 DISCO XXII meeting (invited), 07-10-2010, Honolulu, Hawaii.

Thuroczy, C-E., Brest, IUEM, seminar at LEMAR-CNRS-UMR6539, November 2010, oral presentation.

First results of the complete West Atlantic GEOTRACES transect were presented at 43rd International Liège Colloquium on Ocean Dynamics, Belgium, May 2011, see here below:

Abouchami W., S.J.G. Galer, H. De Baar, A.C. Alderkamp, R. Middag, P. Laan, H. Feldmann, M.O. Andreae, The Southern Ocean Cadmium Isotope Divide, oral presentation

de Baar, Hein (Keynote), Southern Ocean Iron Fertilization; What do we know now, what needs to be investigated, oral presentation

de Baar H.J.W., R. Middag, P. Laan, Dissolved Aluminium and Manganese in the Arctic-Atlantic-Antarctic Oceans, oral presentation

van Heuven S.M.A.C., Salt L., De Baar H.J.W. and Meijer H.A.J., Initial results of ^{14}C in GEOTRACES-NL, oral presentation

van Hulten M.M.P., A. Sterl, A. Tagliabue, J.-C. Dutay, M. Gehlen, H.J.W. de Baar, R. Middag and W. Hazeleger, Aluminium in a general circulation model. Optimising the model or the measurements?, oral presentation

Laan P., M.B. Klunder, D. Bauch, H.J.W. De Baar, IPY – GEOTRACES: Dissolved Fe in the Arctic

Ocean, oral presentation

Rijkenberg MJA, Gerringa, LJA, Laan, P, Schoemann, V, Middag, R, van Heuven, SMAC, Salt, L, van Aken, HM, de Jong, JTM, de Baar, HJW, Dissolved Fe in the Western Atlantic Ocean: distribution, sources, sinks and cycling, oral presentation

Rutgers van der Loeff M., P. Cai, D. Bauch, T. Roeske, M. Klunder, R. Middag, K. Bakker, I. Stimac, Tracers of river inputs in the Transpolar Drift, Arctic Ocean during the Polarstern IPY expedition, 2007, oral presentation

Journal articles

Rob Middag completed his PhD thesis comprising nine research articles on Al and Mn in the Polar Oceans. Similarly several manuscripts/chapters are completed of the theses in progress of Maarten Klunder on Fe in Polar Oceans and Charles-Edouard Thuroczy on Fe Physical- Chemical Speciation in Polar Oceans. Several articles of the Antarctic Polarstern expedition ANT XXIV/3 will appear in a special issue of Deep-Sea Research II.

Abouchami, W., Galer, S.J.G., de Baar, H.J.W., Alderkamp, A.C., Middag, R., Laan, P., Feldmann, H., Andreae, M.O., 2011. Modulation of the Southern Ocean cadmium isotope signature by ocean circulation and primary productivity. *Earth and Planetary Science Letters* 305, 83-91.

Gerringa, L.J.A, Alderkamp, A.-C, Laan, P, Thuróczy, C-E, de Baar, H.J.W., Mills, MM, van Dijken, G.L., van Haren, H., Arrigo, K.R. Iron from melting glacier fuels the algal bloom in Pine Island Bay (Amundsen Sea). *Deep Sea Research II*, special issue DynaLife, Submitted and in review.

Klunder, M.B., D. Bauch, P. Laan, H.J. W. De Baar, S. v. Heuven, S. Ober. Dissolved iron in the Arctic shelf seas and surface waters of the Central Arctic Ocean: Impact of river water and ice-melt. In review for publication in *JGR---Oceans*, March 2011.

Klunder, M.B., P. Laan, H.J.W. De Baar, R. Middag, Dissolved Fe in the Arctic Ocean: important role of hydrothermal sources, shelf input and scavenging removal. In review for publication in *JGR-Oceans*, March 2011.

Klunder, M. B., P. Laan, R. Middag, H. J. W. De Baar, and J. V. Ooijen. 2011. Dissolved iron in the Southern Ocean (Atlantic sector). *Deep Sea Research Part II: Topical Studies in Oceanography* in press

Middag, R., H. J. W. De Baar, P. Laan, and M. B. Klunder. 2011. Fluvial and hydrothermal input of manganese into the Arctic Ocean. *Geochimica Et Cosmochimica Acta* 75: 2393-2408.

Middag, R., H. J. W. De Baar, P. Laan, P. H. Cai, and J. C. Van Ooijen. 2011. Dissolved manganese in the Atlantic sector of the Southern Ocean. *Deep Sea Research Part II: Topical Studies in Oceanography* in press

Middag, R., C. Van Slooten, H. J. W. De Baar, and P. Laan. 2011. Dissolved aluminium in the Southern Ocean. *Deep Sea Research Part II: Topical Studies in Oceanography* in press

Rutgers Van Der Loeff, M., P. Cai, I. Stimac, A. Bracher, R. Middag, M. Klunder, and S. Van Heuven. 2011. 234Th in surface waters: Distribution of particle export flux across the Antarctic Circumpolar Current and in the Weddell Sea during the GEOTRACES expedition ZERO and DRAKE. *Deep Sea Research Part II: Topical Studies in Oceanography* in press

Thuróczy, C-E, Alderkamp, A-C. Laan, P, Gerringa, L.J.A., de Baar H.J.W., Arrigo, K.R. Key role of organic complexation of iron in sustaining phytoplankton blooms in the Pine Island and Amundsen Polynyas (Southern Ocean). *Deep Sea Research II*, special issue DynaLife, Submitted and in review.

Thuróczy, C-E., L.J.A. Gerringa, M. Klunder, P. Laan, M. Le Guitton, H.J.W. de Baar. Distinct trends in the speciation of iron between the shelf seas and the deep basins of the Arctic Ocean, *Journal of Geophysical Research-Oceans*, accepted for publication.

Thuróczy, C. E., L. J. A. Gerringa, M. B. Klunder, R. Middag, P. Laan, K. R. Timmermans, and H. J. W. De Baar. 2010. Speciation of Fe in the Eastern North Atlantic Ocean. *Deep Sea Research Part I*:

Oceanographic Research Papers 57: 1444-1453.

Thuróczy, C. E., L. J. A. Gerringa, M. B. Klunder, P. Laan, and H. J. W. De Baar. 2011. Observation of consistent trends in the organic complexation of dissolved iron in the Atlantic sector of the Southern Ocean. *Deep Sea Research Part II: Topical Studies in Oceanography* in press

Submitted on behalf of all participants by Micha Rijkenberg.

For general information about Netherlands GEOTRACES contact by email to:

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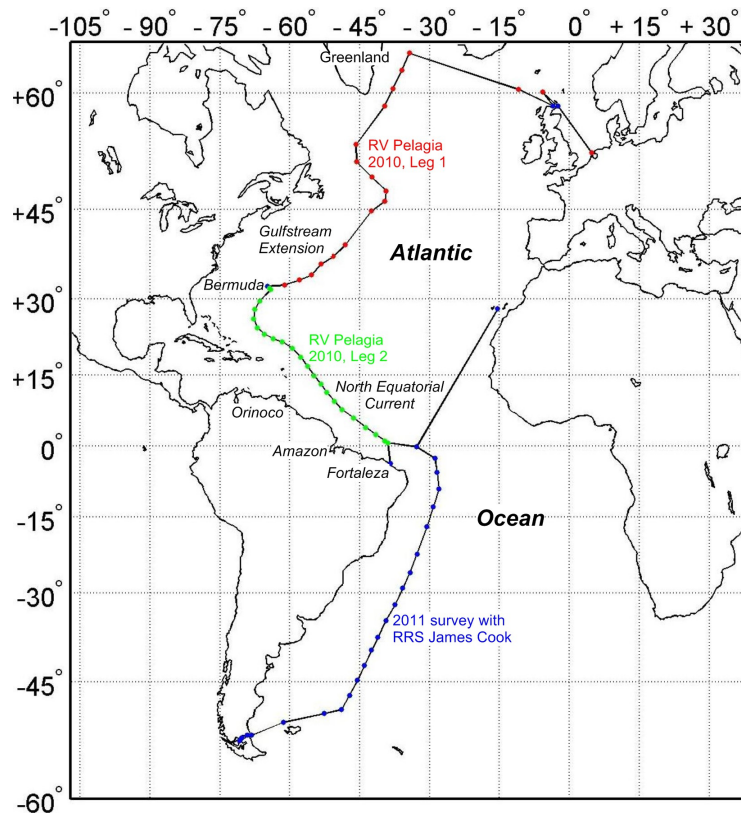


Figure 8: The completed West Atlantic Ocean transect of the Dutch GEOTRACES project.

Ultraclean titanium CTD system with 24 x 27 L PVDF samplers



Coated stainless steel torpedo (FISH) for trace metal clean surface sampling



The ultraclean CTD is placed in the clean room container facility



Trace metal clean sampling inside the clean room container



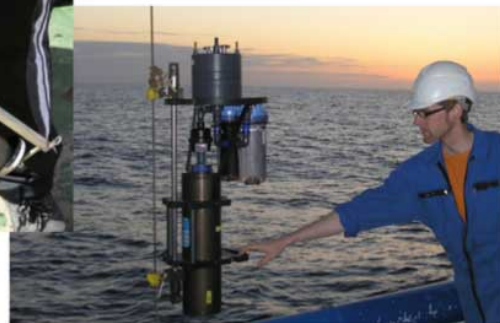
The NIOZ Kley France winch with A frame and 10 km trace metal clean kevlar cable for CTD deployment on the RRS James Cook



Deployment of the high volume 25 L CTD



Mono corer placed underneath the high volume 25L CTD for bottom sediment sampling



In situ pumps for collection of particulate matter

Figure 9: Equipment used during the three Dutch GEOTRACES cruises in the West Atlantic Ocean.



Figure10: On the left clear blue surface seawater at 28°05'N and 67°30'W and on the right the green black surface seawater affected by Amazon river outflow at 05°55'N and 46°25'W.

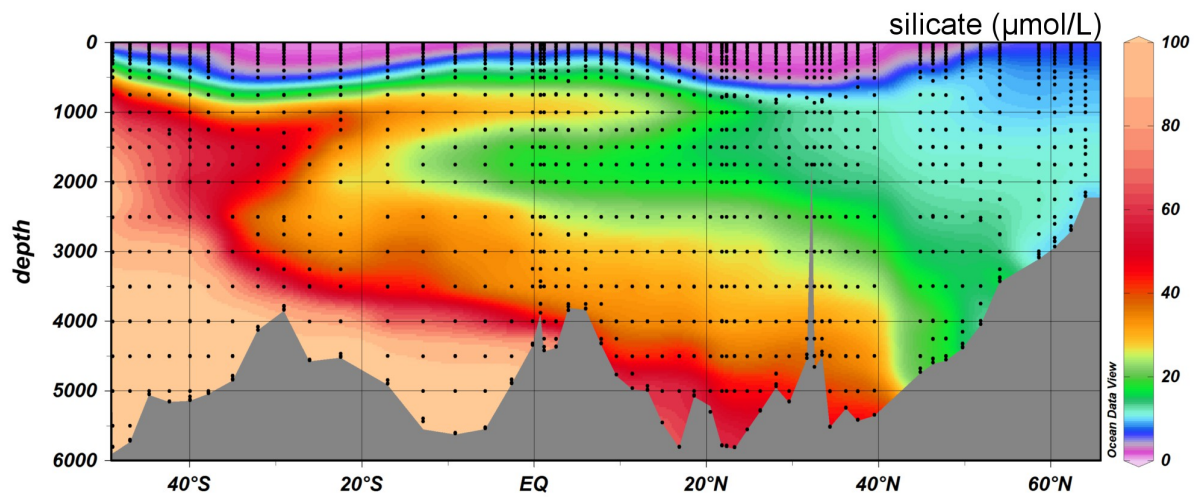


Figure 11: The silicate concentration for the whole West Atlantic Ocean transect.