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# Physical and Chemical Speciation of Iron in the Polar Oceans

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## References

- Alderkamp, A.-C., Mills, M.M., van Dijken, G.L., Laan, P., Thuróczy, C.-E., Gerringsa, L.J.A., De Baar, H.J.W., Payne, C., Tortell, P., Visser, R.J.W., Buma, A.G.J., Arrigo, K.R., **submitted**. Iron from melting glaciers fuels phytoplankton blooms in Amundsen Sea (Southern Ocean); phytoplankton characteristics and productivity. Deep-Sea Research Part II.
- Alldredge, A., Passow, U., Logan, B., **1993**. The abundance and significance of a class of large, transparent organic particles in the ocean. Deep-Sea Research Part I 40 (6), 1131-1140.
- Ambar, I., Serra, N., Neves, F., Ferraira, T., **2008**. Observations of the Mediterranean undercurrent and eddies in the Gulf of Cadiz during 2001. Journal of Marine System 71 (1-2), 195-220.
- Anderson, L.G., Björk, G., Holby, O., Jones, E.P., Kattner, G., Koltermann, K.P., Liljeblad, B., Lindegren, R., Rudels, B., Swift, J.H., **1994**. Water masses and circulation in the Eurasian Basin: results from the Oden 91 expedition. Journal of Geophysical Research, Oceans 99 (C2), 3273-3283.
- Arrigo, K.R., Worthen, D.L., Lizotte, M.P., Dixon, P., Dieckmann G., **1997**. Primary Production in Antarctic Sea Ice. Science 276 (5311), 394-397.
- Arrigo, K.R., Robinson, D. H., Worthen, D. L., Dunbar, R. B., DiTullio, G. R., VanWoert, M., Lizotte, M. P., **1999**. Phytoplankton community structure and the drawdown of nutrients and CO<sub>2</sub> in the Southern Ocean. Science 283 (5400), 365-367.
- Arrigo, K.R., DiTullio, G.R., Dunbar, R.B., Lizotte, M.P., Robinson, D.H., VanWoert, M., Worthen, D.L., **2000**. Phytoplankton taxonomic variability and nutrient utilization and primary production in the Ross Sea. Journal of Geophysical Research 105 (C4), 8827-8846.
- Arrigo, K.R., Dunbar, R.B., Robinson, D.H., Lizotte, M.P., **2002**. Taxon-specific differences in C/P and N/P drawdown for phytoplankton in the Ross Sea, Antarctica. Geophysical Research Letters 29 (19), 1938.
- Arrigo, K.R., Van Dijken, G.L., **2003a**. Impact of iceberg C-19 on Ross Sea primary production. Geophysical Research Letters 30 (16), 1836.
- Arrigo, K.R., Van Dijken, G.L., **2003b**. Phytoplankton dynamics within 37 Antarctic coastal polynyas systems. Journal of Geophysical Research 108 (C8), 3271.

## References

- Arrigo, K.R., Worthen, D.L., Robinson, D. H., **2003**. A coupled ocean-ecosystem model of the Ross Sea: 2. Iron regulation of phytoplankton taxonomic variability and primary production. *Journal of Geophysical Research* 108 (C7), 3231.
- Arrigo, K.R., Lowry, K., van Dijken, G.L., **submitted**. Dynamics of sea ice and phytoplankton in polynyas of the Amundsen Sea, Antarctica. *Deep-Sea Research Part II*.
- Babin, M., Morel, A., Gentili, B., **1996**. Remote sensing of sea surface Sun-induced chlorophyll fluorescence: Consequences of natural variations in the optical characteristics of phytoplankton and the quantum yield of chlorophyll a fluorescence. *International Journal of Remote Sensing* 17 (12), 2417-2448.
- Barbeau, K., Rue, E.L., Bruland, K.W., Butler, A., **2001**. Photochemical cycling of iron in the surface ocean mediated by microbial iron(III)-binding ligands. *Nature* 413 (6854), 409-413.
- Barré, N., Provost, C., Sennechael, N., Lee, J.H., **2008**. Circulation in the Ona Basin, southern Drake Passage. *Journal of Geophysical Research* 113 (C4), C04033.
- Benner, R., **2011**. Loose Ligands and available iron in the Ocean, PNAS, [www.pnas.org/cgi/doi/10.1073/pnas.1018163108](http://www.pnas.org/cgi/doi/10.1073/pnas.1018163108).
- Bergquist, B.A., Boyle, E.A., **2006**. Dissolved iron in the tropical and subtropical Atlantic Ocean. *Global Biogeochemical Cycles* 20 (1), GB1015.
- Bergquist, B.A., Wu, J., Boyle, E.A., **2007**. Variability in oceanic dissolved iron is dominated by the colloidal fraction. *Geochimica et Cosmochimica Acta* 71 (12), 2960-2974.
- Bonnet, S., Guieu, C., **2004**. Dissolution of atmospheric iron in seawater, *Geophysical Research Letters* 31 (3), L03303.
- Bowie, A.R., Whitworth, D.J., Achterberg, E.P., Mantoura, R.F.C., Worsfold, P.J., **2002**. Biogeochemistry of Fe and other trace elements (Al, Co, Ni) in the upper Atlantic Ocean. *Deep-Sea Research Part I* 49 (4), 605-636.
- Boye, M., Van Den Berg, C.M.G., **2000**. Iron availability and the release of iron-complexing ligands by *Emiliania huxleyi*. *Marine Chemistry* 70 (4), 277-287.
- Boye, M., Van Den Berg, C.M.G., De Jong, J.T.M., Leach, H., Croot, P., De Baar, H.J.W., **2001**. Organic complexation of iron in the Southern Ocean. *Deep-Sea Research Part I* 48 (6), 1477-1497.

## References

- Boye, M., Aldrich, A.P., Van Den Berg, C.M.G., De Jong, J.T.M., Veldhuis, M., De Baar, H.J.W., **2003**. Horizontal gradient of the chemical speciation of iron in surface waters of the northeast Atlantic Ocean. *Marine Chemistry* 80 (2-3), 129-143.
- Boye, M., Nishioka, J., Croot, P.L., Laan, P., Timmermans, K.R., De Baar, H.J.W., **2005**. Major deviations of iron complexation during 22 days of a mesoscale iron enrichment in the open Southern Ocean. *Marine Chemistry* 96 (3-4), 257-271.
- Boye, M., Nishioka, J., Croot, P.L., Laan, P., Timmermans, K.R., Strass, V.H., Takeda, S., De Baar, H.J.W., **2010**. Significant portion of dissolved organic Fe-complexes in fact is Fe colloids. *Marine Chemistry* 126 (1-4), 20-27.
- Breitbarth, E., Achterberg, E.P., Ardelan, M.V., Baker, A.R., Bucciarelli, E., Chever, F., Croot, P.L., Duggen, S., Gledhill, M., Hasselov, M., Hassler, C., Hoffmann, L.J., Hunter, K.A., Hutchins, D.A., Ingri, J., Jickells, T., Lohan, M.C., Nielsdottir, M.C., Sarthou, G., Schoemann, V., Trapp, J.M., Turner, D.R., Ye, Y., **2010**. Iron biogeochemistry across marine systems - progress from the past decade. *Biogeosciences* 7 (3), 1075-1097.
- Buck, K.N., Bruland, K.W., **2007**. The physicochemical speciation of dissolved iron in the Bering Sea, Alaska. *Limnology and Oceanography* 52 (5), 1800-1808.
- Buck, K.N., Lohan, M.C., Berger, C.J.M., Bruland, K.W., **2007**. Dissolved iron speciation in two distinct river plumes and an estuary: Implications for riverine iron supply. *Limnology and Oceanography* 52 (2), 843-855.
- Buffle, J., Leppard, G.G., **1995a**. Characterization of aquatic colloids and Macromolecules. 1. Structure and behaviour of colloidal material. *Environmental Science and Technology* 29 (9), 2169-2175.
- Buffle, J., Leppard, G.G., **1995b**. Characterization of aquatic colloids and Macromolecules. 2. Key role of Physical structures on analytical results. *Environmental Science and Technology* 29 (9), 2176-2184.
- Buma, A.G.J., De Baar, H.J.W., Nolting, R.F., Vanbennekom, A.J., **1991**. Metal enrichment experiments in the Weddell-Scotia Seas - Effects of iron and manganese on various plankton communities. *Limnology and Oceanography* 36 (8), 1865-1878.
- Butler, A., **1998**. Acquisition and utilization of transition metal ions by marine organisms. *Science* 281 (5374), 207-210.

## References

- Butler, A., **2005**. Marine siderophores and microbial iron mobilization. *BioMetals* 18 (4), 369-374.
- Carlson, C.A., Hansell, D.A., **2003**. The contribution of DOM on the biogeochemistry of the Ross Sea. In: Biogeochemical cycles in the Ross Sea, AGU, Antarctic Research Series 78, 123-142.
- Carmack, E.C., Foster, T.D., **1975**. On the flow of water out of the Weddell Sea. *Deep-Sea Research* 22 (11), 711-724.
- Carmack, E.C., **1977**. Water characteristics of the Southern Ocean south of the Polar Front. In: Angel, M. (Ed.), *A Voyage of Discovery, George Deacon 70th Anniversary Volume*. Pergamon Press, Oxford, 15-41.
- Chen, M., Wang, W.-X., Guo, L., **2003**. Phase partitioning and solubility of iron in natural seawater controlled by dissolved organic matter. *Global Biogeochemistry Cycles* 18 (4), GB 4013.
- Coale, K.H., Johnson, K.S., Fitzwater, S.E., Gordon, R.M., Tanner, S., Chavez, F.P., Ferioli, L., Sakamoto, C., Rogers, P., Millero, F.J., Steinberg, P., Nightingale, P., Cooper, D., Cochlan, W.P., Landry, M.R., Constantinou, J., Rollwagen, G., Trasvina, A., Kudela, R., **1996**. A massive phytoplankton bloom induced by an ecosystem-scale iron fertilization experiment in the equatorial Pacific Ocean. *Nature* 383 (6600), 495-501.
- Croot, P.L., Johanson, M., **2000**. Determination of iron speciation by cathodic stripping voltammetry in seawater using the competing ligand 2-(2-Thiazolylazo)-p-cresol (TAC). *Electroanalysis* 12 (8), 565-576.
- Croot, P.L., Bowie, A.R., Frew, R.D., Maldonado, M.T., Hall, J.A., Safi, K.A., La Roche, J., Boyd, P.W., Law, C.S., **2001**. Retention of dissolved iron and Fe-II in an iron induced Southern Ocean phytoplankton bloom. *Geophysical Research Letters* 28 (18), 3425-3428.
- Croot, P.L., Streu, P., Baker, A.R., **2004a**. Short residence time for iron in the surface seawater impacted by atmospheric dry deposition from Saharan dust events. *Geophysical Research Letters* 31 (23), L23S08.
- Croot, P.L., Andersson, K., Öztürk, M., Turner, D.R., **2004b**. The distribution and speciation of iron along 6°E in the Southern Ocean. *Deep-Sea Research Part II* 51 (22-24), 2857-2879.

## References

- Cullen, J.T., Bergquist, B.A., Moffett, J.W., **2006**. Thermodynamic characterization of the partitioning of iron between soluble and colloidal species in the Atlantic Ocean. *Marine Chemistry* 98 (2-4), 295-303.
- Da Silva, J.J.R.F., Williams, R.J.P., **1991**. The Biological Chemistry of the Elements: The Inorganic Chemistry of Life, Oxford University Press, Oxford.
- De Baar, H.J.W., Buma, A.G.J., Nolting, R.F., Cadée, G.C., Jacques, G., Tréguer, P.J., **1990**. On iron limitation of the Southern Ocean: experimental observations in the Weddell and Scotia Seas. *Marine Ecology Progress Series* 65 (2), 105-122.
- De Baar, H.J.W., De Jong, J.T.M., Bakker, D.C.E., Löscher, B.M., Veth, C., Bathmann, U., Smetacek, V., **1995**. Importance of iron for plankton blooms and carbon dioxide drawdown in the Southern Ocean. *Nature* 373 (6513), 412-415.
- De Baar, H.J.W., De Jong, J.T.M., **2001**. Distributions, sources and sinks of iron in seawater. In: D.R. Turner and K.A. Hunter (eds.), *The Biogeochemistry of Iron in Seawater*. Wiley and sons Chapter 5, Fig 5 pp. 135.
- De Baar, H.J.W., La Roche, J., **2003**. Metals in the Oceans; Evolution, Biology and Global Change. In: *Marine Scientific frontiers for Europe* (eds. Lamy, F., Wefer, G.), 79-105, Springer Verlag, Berlin, Germany.
- De Baar, H.J.W., Boyd, P.W., Coale, K.H., Landry, M.R., Tsuda, A., Assmy, P., Bakker, D.C.E., Bozec, Y., Barber, R.T., Brzezinski, M.A., Buesseler, K.O., Boye, M., Croot, P.L., Gervais, F., Gorbunov, M.Y., Harrison, P.J., Hiscock, W.T., Laan, P., Lancelot, C., Law, C.S., Levasseur, M., Marchetti, A., Millero, F.J., Nishioka, J., Nojiri, Y., Van Oijen, T., Riebesell, U., Rijkenberg, M.J.A., Saito, H., Takeda, S., Timmermans, K.R., Veldhuis, M.J.W., Waite, A.M., Wong, C.S., **2005**. Synthesis of Iron Fertilization Experiments: From the Iron Age in the Age of Enlightenment. *Journal of Geophysical Research* 110, C09S16.
- De Baar, H.J.W., Timmermans, K.R., Laan, P., De Porto, H.H., Ober, S., Blom, J.J., Bakker, M.C., Schilling, J., Sarthou, G., Smit, M.G., Klunder, M., **2008a**. Titan: A new facility for ultraclean sampling of trace elements and isotopes in the deep oceans in the international Geotraces program. *Marine Chemistry* 111 (1-2), 4-21.
- De Baar H.J.W., Gerringa, L.J.A., Laan, P., Timmermans, K.R., **2008b**. Efficiency of carbon removal per added iron in ocean iron fertilization. *Marine Ecology Progress Series* 364 , 269-282.

## References

- De Jong, J.T.M., Den Das, J., Bathmann, U., Stoll, M.H.C., Kattner, G., Nolting, R.F., De Baar, H.J.W., **1998**. Dissolved iron at subnanomolar levels in the Southern Ocean as determined by ship-board analysis. *Analytica Chimica Acta* 377 (2-3), 113-124.
- Deacon, G.E.R., **1979**. The Weddell Gyre. *Deep-Sea Research* 26A, 981-995.
- Desboeufs, K.V., Losno, R., Colin, J.L., **2001**. Factors influencing aerosol solubility during cloud processes, *Atmospheric Environment* 35 (20), 3529-3537.
- Duce, R.A., Tindale, N.W., **1991**. Atmospheric transport of iron and its deposition in the ocean, *Limnology and Oceanography* 36 (8), 1715-1726.
- Eppley, R.W., Peterson, B.J., **1979**. Particulate organic matter flux and planktonic new production in the deep ocean. *Nature* 282 (5740), 677-680.
- Fahrbach, E., Hoppema, M., Rohardt, G., Schröder, M., Wisotzki, A., **2004**. Decadal-scale variations of water mass properties in the deep Weddell Sea. *Ocean Dynamics* 54 (1), 77-91.
- Fisher, G., Fütterer, D., Gersond, R., Honjo, S., Ostermann, D., Wefer, G., **1988**. Seasonal variability of particle flux in the Weddell Sea and its relation to ice cover. *Nature* 335, 426-428.
- Fitzwater, S.E., Coale, K.H., Gordon, R.M., Johnson, K.S., Ondrusek, M.E., **1996**. Iron deficiency and phytoplankton growth in the equatorial Pacific. *Deep-Sea Research II Part 43* (4-6), 995-1015.
- Fitzwater, S.E., Johnson, K.S., Gordon, R.M., Coale, K.H., Smith Jr., W.O., **2000**. Trace metal concentrations in the Ross Sea and their relationship with nutrients and phytoplankton growth. *Deep-Sea Research II* 47 (15-16), 3159-3179.
- Flores, H., **2009**. Frozen Desert Alive. Ph.D. Thesis, University of Groningen, The Netherlands. Electronic version available at:  
<http://www.rug.nl/bibliotheek/catalogibestanden/elekpubrug/dissertaties/index>
- Foldvik, A., Gammelsrød, T., **1988**. Notes on Southern Ocean hydrography, sea-ice and bottom water formation. *Palaeogeography, Palaeoclimatology, Palaeoecology* 67 (1-2), 3-17.
- GEOTRACES Planning Group, **2006**. GEOTRACES Science Plan. Scientific Committee on Oceanic Research, Baltimore, Maryland.

## References

- Gerringa, L.J.A., Herman, P.M.J., Poortvliet, T.C.W., **1995**. Comparison of the linear Van Den Berg/Ružić transformation and a non-linear fit of the Langmuir isotherm applied to Cu speciation data in the estuarine environment. *Marine Chemistry* 48 (2), 131-142.
- Gerringa, L.J.A., Veldhuis, M.J.W., Timmermans, K.R., Sarthou, G., De Baar, H.J.W., **2006**. Co-variance of dissolved Fe-binding ligands with phytoplankton characteristics in the Canary Basin. *Marine Chemistry* 102 (3-4), 276-290.
- Gerringa, L.J.A., Rijkenberg, M.J.A., Wolterbeek, H.Th., Verburg, T.G., Boye, M., De Baar, H.J.W., **2007**. Kinetic study reveals Fe-binding ligand, which affects the solubility of Fe in the Scheldt estuary. *Marine Chemistry* 103 (1-2), 30-45.
- Gerringa, L.J.A., Blain, S., Laan, P., Sarthou, G., Veldhuis, M.J.W., Brussaard, C.P.D., Viollier, E., Timmermans, K.R., **2008**. Fe-binding organic ligands near the Kerguelen Archipelago in the Southern Ocean (Indian sector). *Deep-Sea Research Part II* 55, 606-621.
- Gerringa, L.J.A., Alderkamp, A.-C., Laan, P., Thuróczy, C.-E., De Baar, H.J.W., Mills, M.M., Van Dijken, G.L., Van Haren, H., Arrigo, K.R., **submitted** Fe from melting glacier fuels the algal bloom in Pine Island Bay (Amundsen Sea, Southern Ocean ). *Deep-Sea Research Part II*.
- Gledhill, M., Van Den Berg, C.M.G., **1994**. Determination of complexation of iron (III) with natural organic complexing ligands in sea water using cathodic stripping voltammetry. *Marine Chemistry* 47 (1), 41-54.
- Giulivi, C. F., Jacobs, S.S., **1997**. Oceanographic data in the Amundsen and Bellingshausen seas, NB Palmer cruise 9402, Feb–Mar 1994, Tech. Rep. LDEO-97-3, 330 pp., Lamont-Doherty Earth Obs. Of Columbia University, Palisades, N. Y.
- Gledhill, M., McCormack, P., Ussher, S., Achterberg, E.P., Mantoura, R.F.C., Worsfold, P.J., **2004**. Production of siderophore type chelates by mixed bacterioplankton populations in nutrient enriched seawater incubations. *Marine Chemistry* 88 (1-2), 75-83.
- Gouretski, V.V., Danilov, A.I., **1993**. Weddell Gyre: structure of the eastern boundary. *Deep-Sea Research Part I* 40 (3), 561-582.
- Grashoff, K., Erhardt, M., Kremling, K., **1983**. Methods in Seawater Analyses. Verlag Chemie, Weinheim, Germany. 419 pp.

## References

- Grotti, M., Soggia, F., Ianni, C., Frache, R., **2005**. Trace metals distributions in coastal sea ice of Terra Nova Bay, Ross Sea, Antarctica. Antarctic Science 17 (2), 289-300.
- Guay, C., Falkner, K., **1997**. Barium as a tracer of Arctic halocline and river waters. Deep-Sea Research Part II (44), 1543-1569.
- Hassler, C.S., Schoemann, V., **2009**. Bioavailability of organically bound Fe to model phytoplankton of the Southern Ocean. Biogeosciences 6, 2281-2296.
- Hassler, C.S., Alasonati, E., Mancuso Nichols, C.A., Slaveykova, V.I., **2011**. Exopolysaccharides produced by bacteria isolated from the pelagic Southern Ocean - Role in Fe binding, chemical reactivity, and bioavailability. Marine Chemistry 123 (1-4), 88-98.
- Hayase, K., Tsubota, H., Sunada, I., Goda, S., Yamazaki, H., **1988**. Vertical distribution of fluorescent organic matter in the North Pacific. Marine Chemistry 25(4), 373.
- Hayase, K., Shinozuka, N., **1995**. Vertical distribution of fluorescent organic matter along with AOU and nutrients in the equatorial Central Pacific. Marine Chemistry 48 (3-4), 283-290.
- Haygood, M.G., Holt, P.D., Butler, A., **1993**. Aerobactin production by a planktonic marine Vibrio sp. Limnology and Oceanography 38 (5), 1091-1097.
- Hirose, K., **2007**. Metal-organic matter interaction: Ecological roles of ligands in oceanic DOM. Applied Geochemistry 22 (8), 1636-1645.
- Hudson, R.J.M., Rue, R.L., Bruland, K.W., **2003**. Modeling complexometric titrations of natural water samples. Environmental Science and Technology 37 (8), 1553-1562.
- Hunter, K.A., Boyd, P.W., **2007**. Iron-binding ligands and their role in the ocean biogeochemistry of iron. Environmental Chemistry 4 (4), 221-232.
- Hutchins, D.A., Witter, A.E., Butler, A., Luther, G.W., **1999a**. Competition among marine phytoplankton for different chelated iron species. Nature 400 (6747), 858-861.
- Hutchins, D.A., Franck, V., Brzezinski, M.A., Bruland, K.W., **1999b**. Inducing phytoplankton iron limitation in iron-replete coastal waters with a strong chelating ligand. Limnology and Oceanography 44 (4), 1009-1018.

## References

- Jacobs, S.S., Hellmer, H.H., **1996**. Antarctic ice sheet melting in the Southeast Pacific. *Geophysical Research Letters* 23 (9), 957-960.
- Jenkins, A., Dutrieux, P., Jacobs, S.S., McPhail, S.D., Perrett, J.R., Webb, A.T., White D., **2010**. Observations beneath Pine Island Glacier in West Antarctica and implications for its retreat. *Nature Geoscience* 3 (7), 468-472.
- Jickells, T.D., An, Z.S., Andersen, K.K., Baker, A.R., Bergametti, G., Brooks, N., Cao, J.J., Boyd, P.W., Duce, R.A., Hunter, K.A., Kawahata, H., Kubilay, N., La Roche, J., Liss, P.S., Mahowald, N., Prospero, J.M., Ridgwell, A.J., Tegen, I., Torres, R., **2005**. Global iron connections between desert dust, ocean biogeochemistry, and climate. *Science* 308 (5718), 67-71.
- Johnson, K.S., Gordon, R.M., Coale, K.H., **1997**. What controls dissolved iron concentrations in the world ocean? *Marine Chemistry* 57 (3-4), 137-161.
- Johnson, K.S., Boyle, E., Bruland, K., Measures, C., Moffett, J., Aquilarislas, A., Barbeau, K., Cai, Y., Chase, Z., Cullen, J., Doi, T., Elrod, V., Fitzwater, S., Gordon, M., King, A., Laan, P., Laglera-Baquer, L., Landing, W., Lohan, M., Mendez, J., Milne, A., Obata, H., Ossiander, L., Plant, J., Sarthou, G., Sedwick, P., Smith, G.J., Sohst, B., Tanner, S., Van Den Berg, S., Wu, J., **2007**. Developing Standards for Dissolved Iron in seawater. *Eos Transactions American Geophysical Union* 88 (11), 131-132
- Journet, E., Desboeufs, K.V., Caquineau, S., Colin, J.L., **2008**. Mineralogy as a critical factor of dust iron solubility. *Geophysical Research Letters* 35 (7), 47-51.
- Kepkay, P.E., **1994**. Particle aggregation and the biological reactivity of colloids. *Marine Ecology Progress Series* 109 (2-3), 293-304.
- Kiefer, D.A., **1973**. Chlorophyll a fluorescence in marine centric diatoms: Responses of chloroplasts to light and nutrient stress. *Marine Biology* 23 (1), 39-46.
- Klatt, O., Fahrbach, E., Hoppema, M., Rohardt, G., **2005**. The transport of the Weddell Gyre across the Prime Meridian. *Deep-Sea Research Part II* 52, 513-528.
- Klunder, M.B., Laan, P., Middag, R., De Baar, H.J.W., van Ooijen, J.C., **2011**. Dissolved Fe in the Southern Ocean (Atlantic sector). *Deep-Sea Research Part II*, doi:10.1016/j.dsr2.2010.10.042.

## References

- Klunder, M.B., Bauch, D., Laan, P., De Baar, H.J.W., Van Heuven S., Ober, S.. Dissolved iron in the Arctic shelf seas and surface waters of the Central Arctic Ocean: Impact of Arctic river water and ice-melt. **Submitted** to Journal of Geophysical Research-Oceans (a).
- Klunder, M.B., Laan, P., Middag, R., De Baar, H.J.W.. Dissolved Fe in the Arctic Ocean: important role of hydrothermal sources, shelf input and scavenging removal. **Submitted** to Journal of Geophysical Research-Oceans (b).
- Klunder, M.B., Laan, P., De Baar, H.J.W., **in prep.** Dissolved Fe in the Weddell Sea and in the Drake Passage. Thesis in preparation.
- Kondo, Y., Takeda, S., Nishioka, J., Obata, H., Furuya, K., Johnson, W.K., Wong, C.S., **2008**. Organic iron (III) complexing ligands during an iron enrichment experiment in the western subarctic North Pacific. *Geophysical Research Letters* 35 (12), L12601.
- Kuma, K., Nishioka, J., Matsunaga, K., **1996**. Controls on iron(III) hydroxide solubility in seawater: The influence of pH and natural organic chelators. *Limnology and Oceanography* 41 (3), 396-407.
- Kuma, K., **2002**. Variation in iron(III) solubility and iron concentration in the northwestern North Pacific Ocean. *Limnology and Oceanography* 47(3), 885-892.
- Laës, A., Blain, S., Laan, P., Achterberg, E.P., Sarthou, G., De Baar, H.J.W., **2003**. Deep dissolved iron profiles in the eastern North Atlantic in relation to water masses. *Geophysical Research Letters* 30 (17), 1902.
- Laglera, L.M., Van Den Berg, C.M.G., **2007**. Wavelength dependence of the photochemical reduction of iron in Arctic seawater. *Environmental Sciences and Technology* 41 (7), 2296-2302.
- Lam, P.J., Bishop, J.K.B., Henning, C.C., Marcus, M.A., Waychunas, G.A., Fung, I.Y., **2006**. Wintertime phytoplankton bloom in the subarctic Pacific supported by continental margin iron. *Global Biogeochemical Cycles* 20 (1), GB106.
- Lam, P.J., Bishop, J.K.B., **2008**. The continental margin is a key source of iron to the HNLC North Pacific Ocean. *Geophysical Research Letters* 35 (7), L07608.
- Lannuzel, D., Schoemann, V., De Jong, J., Tison, J.L., Chou, L., **2007**. Distribution and biogeochemical behaviour of iron in the East Antarctic sea ice. *Marine Chemistry* 106 (1-2), 18-32.

## References

- Lannuzel, D., Schoemann, V., De Jong, J., Chou, L., Delille, B., Becquevort, S., Tison, J.L., **2008**. Iron study during a time series in the western Weddell pack ice. *Marine Chemistry* 108 (1-2), 85-95.
- Lannuzel, D., Schoemann, V., De Jong, Pasquer, B., Van Der Merwe, P., Masson, F., Tison, J.-L., Bowie, A., **2010**. Distribution of dissolved iron in Antarctic sea ice: Spatial, seasonal, and inter-annual variability. *Journal of Geophysical Research* 115, G03022.
- Lewis, B.L., Holt, P.D., Taylor, S.W., Wilhelm, S.W., Trick, C.G., Butler, A., Luther III, G.W., **1995**. Voltammetric estimation of iron(II1) thermodynamic stability constants for catecholate siderophores isolated from marine bacteria and cyanobacteria. *Marine Chemistry* 50 (1-4), 179-188.
- Liu, X. Millero, F.J., **2002**. The solubility of iron in seawater. *Marine Chemistry* 77 (1), 43-54.
- Logan, B.E., Passow, U., Alldredge, A.L., Grossart, H.-P., Simon, M., **1995**. Rapid formation and sedimentation of large aggregates is predictable from aggregation rates (half lives) of transparent exopolymer particles (TEP). *Deep-Sea Research Part II* 42 (1), 203-214.
- Lohan, M.C., Aguilar-Islas, A.M., Franks, R.P., Bruland, K.W., **2005**. Determination of iron and copper in seawater at pH 1.7 with a new commercially available chelating resin, NTA Superflow. *Analytica Chimica Acta* 530 (1), 121-129.
- Macrellis, H.M., Trick, C.G., Rue, E.L., Smith, G., Bruland, K.W., **2001**. Collection and detection of natural iron-binding ligands from seawater. *Marine Chemistry* 76 (3), 175-187.
- Maldonado, M.T., Strzepek, R.F., Sander, S., Boyd, P.W., **2005**. Acquisition of iron bound to strong organic complexes, with different Fe-binding groups and photochemical reactivities, by plankton communities in Fe-limited subantarctic waters. *Global Biogeochemical Cycles* 19 (4), GB4S23.
- Mantyla, A.W., Reid, J.L., **1983**. Abyssal Characteristics of the World Ocean Waters. *Deep-Sea Research Part A* 30 (8), 805-833.
- Martin, J.H., Gordon, R.M., **1988**. Northeast Pacific iron distributions in relation to phytoplankton productivity. *Deep-Sea Research Part A* 34 (2), 177-196.
- Martin, J.H., Gordon, R.M., Fitzwater, S.E., **1990**. Iron in Antarctic waters. *Nature* 345 (6271), 156-158.

## References

- Martin, J.H., Gordon, R.M., Fitzwater, S.E., **1991**. The case for iron. Limnology and Oceanography 36 (8), 1793-1802.
- Martinez, J.S., Butler, A., **2007**. Marine amphiphilic siderophores: Marinobactin structure, uptake, and microbial partitioning. Journal of Inorganic Biochemistry 101 (11-12), 1692-1698.
- Measures, C.I., Yeats, P.A., Schmidt, D., **1995**. The hydrographic setting of the IOC base-line cruise to the eastern Atlantic 30-degrees-S to 35-degrees-N. Marine Chemistry 49 (4), 243-252.
- Measures, C.I., **1999**. The role of entrained sediments in sea ice in the distribution of aluminium and iron in the surface waters of the Arctic Ocean. Marine Chemistry 68 (1-2), 59-70.
- Measures, C.I., Landing, W.M., Brown, M.T., Buck, C.S., **2008**. High-resolution Al and Fe data from the Atlantic Ocean CLIVAR-CO<sub>2</sub> repeat hydrography A16N transect: extensive linkages between atmospheric dust and upper ocean geochemistry. Global Biogeochemical Cycles 22 (1), GB1005.
- Meiners, K., Krembs, C., Gradinger, R., **2008**. Exopolymer particles: microbial hotspots of enhanced bacterial activity in Arctic fast ice (Chukchi Sea), Aquatic Microbial Ecology 52, 195-207.
- Middag, R., Klunder, M.B., Thuróczy, C.-E., Gerringa, L.J.A., De Baar, H.J.W., Timmermans, K.R., Laan, P. Aluminium, iron and manganese in relation to the Silicon cycle in the North East Atlantic Ocean. Personal communication.
- Middag, R., De Baar, H.J.W., Laan, P., Baker, K., **2009**. Dissolved aluminium and the silicon cycle in the Arctic Ocean. Marine chemistry 115 (3-4), 176-195.
- Middag, R., van Slooten, C., de Baar, H.J.W., Laan, P., **2011a**. Dissolved aluminium in the Southern Ocean. Deep-Sea Research Part II.
- Middag, R., De Baar, H.J.W., Laan, P., Cai, P., Van Ooijen, J.C., **2011b**. Dissolved Manganese in the Atlantic sector of the Southern Ocean. Deep-Sea Research Part II, doi:10.1016/j.dsr2.2010.10.043.
- Millero, F.J., Yao, W., Aicher, J., **1995**. The speciation of Fe(II) and Fe(III) in natural waters. Marine Chemistry 50 (1-4), 21-39.
- Millero, F.J., **1998**. Solubility of Fe(III) in seawater. Earth and Planetary Science Letters 154 (1-4), 323-329.

## References

- Mills, M.M., Alderkamp, A.-C., Thuróczy, C.-E., van Dijken, G.L., Laan, P., De Baar, H.J.W., Arrigo, K.R., **submitted**. Phytoplankton biomass and pigment responses to Fe amendments in the Pine Island and Amundsen polynyas. Submitted to Deep-Sea Research Part II.
- Moore, J.K., Braucher, O., **2008**. Sedimentary and mineral dust sources of dissolved iron to the world ocean. Biogeosciences 5 (3), 631-656.
- Nishioka, J., Takeda, S., **2000**. Change in the concentrations of iron in different size fractions during growth of the oceanic diatom *Chaetoceros sp.*: importance of small colloidal iron. Marine Biology 137 (2), 231-238.
- Nishioka, J., Takeda, S., Wong, C.S., Johnson, W.K., **2001**. Sized-fractionated iron concentrations in the northeast Pacific Ocean: distribution of soluble and small colloidal iron. Marine Chemistry 74 (2-3), 157-179.
- Nishioka, J., Takeda, S., De Baar, H.J.W., Croot, P.L., Boye, M., Laan, P., Timmermans, K.R., **2005**. Changes in the concentration of iron in different size fractions during an iron enrichment experiment in the open Southern Ocean. Marine Chemistry 95 (1-2), 51-63.
- Nistche, F.O., Jacobs, S.S., Larter, R.D., Gohl, K., **2007**. Bathymetry of the Amundsen Sea continental shelf: Implications for geology, oceanography, and glaciology. Geochemistry Geophysics Geosystems 8, Q10009.
- Nolting, R.F., Gerringa, L.J.A., Swagerman, M.J.W., Timmermans, K.R., De Baar, H.J.W., **1998**. Fe(III) speciation in the high nutrient, low chlorophyll Pacific region of the Southern Ocean. Marine Chemistry 62 (3-4), 335-352.
- Orsi, A.H., Johnson, G.C., Bullister, J.L., **1999**. Circulation, mixing, and production of Antarctic Bottom Water. Progress in Oceanography 43, 55-109.
- Passow, U., **1991**. Species-specific sedimentation and sinking velocities of diatoms. Marine Biology 108 (3), 449-455.
- Pollard, R.T., Lucas, M.I., Read, J.F., **2002**. Physical controls on biogeochemical zonation in the Southern Ocean. Deep-Sea Research Part II 49 (16), 3289-3305.
- Powell, R.T., Donat, J.R., **2001**. Organic complexation and speciation of iron in the South and Equatorial Atlantic. Deep-Sea Research Part II 48 (13), 2877-2893.
- Pusceddu, A., Cattaneo-Vietti, R., Albertelli, G., Fabiano, M., **1999**. Origin, biochemical composition and vertical flux of particulate organic matter under

## References

- the pack ice in Terra Nova Bay (Ross Sea, Antarctica) during late summer 1995. *Polar Biology* 22 (2), 124-132.
- Raiswell, R., Benning, L.G., Tranter, M., Tulaczyk, S., **2008**. Bioavailable iron in the Southern Ocean: the significance of the iceberg conveyor belt. *Geochemical Transactions* 9, 7.
- Reid, R.T., Live, D.H., Faulkner, D.J., Butler, A., **1993**. A siderophore from a marine bacterium with an exceptional ferric ion affinity constant. *Nature* 366 (6454), 455-458.
- Reinthalter, T., Van Aken, H., Veth, C., Aristegui, J., Robinson, C., Williams, P.J.Le.B., Lebaron P., Herndl, G., **2006**. Prokaryotic respiration and production in the meso- and bathypelagic realm of the eastern and western North Atlantic basin. *Limnology and Oceanography* 51 (3), 1262-1273.
- Riedel, A., Michel, C., Gosselin, M., LeBlanc, B., **2007**. Enrichment of nutrients, exopolymeric substances and microorganisms in newly formed sea ice on the Mackenzie shelf. *Marine Ecology Progress Series* 342, 55-67.
- Riedel, A., Michel, C., Gosselin, M., LeBlanc, B., **2008**. Winter-spring dynamics in sea ice carbon cycling in the coastal Arctic Ocean. *Journal of Marine Systems* 74(3-4), 918-932.
- Rignot, E., Bamber, J.L., Van Den Broek, M.R., Davis, C., Li, Y.H., Van De Berg, W.J., Van Meijgaard, E., **2008**. Recent Antarctic ice mass loss from radar interferometry and regional climate modelling. *Nature Geoscience* 1 (2), 106-110.
- Rijkenberg, M.J.A., Powell, C.F., Dall’Osto, M., Nielsdottir, M.C., Patey, M.D., Hill, P.G., Baker, A.R., Jickels, T.D., Harrison, R.M., Achterberg, E.P., **2008a**. Changes in iron speciation following a Saharan dust event in the tropical North Atlantic Ocean. *Marine Chemistry* 110 (1-2), 56-67.
- Rijkenberg, M.J.A., Gerringsa, L.J.A., Timmermans, K.R., Fischer, A.C., Kroon, K.J., Buma, A.G.J., Wolterbeek, H.Th., De Baar, H.J.W., **2008b**. Enhancement of reactive iron pool by marine diatoms. *Marine Chemistry* 109 (1-2), 29-44.
- Rudels, B., Muench, R.D., Gunn, J., Schauer, U., Friedrich, H.J., **2000**. Evolution of the Arctic Ocean boundary current north of the Siberian Shelves. *Journal of Marine Systems* 25 (1), 77-99.
- Rue, E.L., Bruland, K.W., **1995**. Complexation of iron(III) by natural organic ligands in the Central North Pacific as determined by a new competitive ligand

## References

- equilibration/adsorptive cathodic stripping voltammetric method. *Marine Chemistry* 50 (1-4), 117-138.
- Rue, E.L., Bruland, K.W., **1997**. The role of organic complexation on ambient iron chemistry in the equatorial Pacific Ocean and the response of a mesoscale iron addition experiment. *Limnology and Oceanography* 42 (5), 901-910.
- Saito, M.A., Sigman, D.M., Morel, F.M.M., **2003**. The bioinorganic chemistry of the ancient ocean: the co-evolution of cyanobacterial metal requirements and biogeochemical cycles at the Archean-Proterozoic boundary? *Inorganica Chimica Acta* 356, 308-318.
- Sarthou, G., Baker, A.R., Kramer, J., Laan, P., Laës, A., Ussher, S., Achterberg, E.P., De Baar, H.J.W., Timmermans, K.R., Blain, S., **2007**. Influence of atmospheric inputs on the iron distribution in the subtropical North-East Atlantic Ocean. *Marine Chemistry* 104 (3-4), 186-202.
- Sarthou, G., Vincent, D., Christaki, U., Obernosterer, I., Timmermans, K.R., Brussaard, C.P.D., **2008**. The fate of biogenic iron during a phytoplankton bloom induced by natural fertilisation: Impact of copepod grazing. *Deep-Sea Research Part II* 55 (5-7), 734-751.
- Sedwick, P.N., DiTullio, G.R., 1997. Regulation of algal blooms in Antarctic shelf waters by release of iron from melting sea ice. *Geophysical Research Letters* 24 (20), 2515-2518.
- Sedwick, P.N., DiTullio, G.R., Mackey, D.J., **2000**. Iron and manganese in the Ross Sea, Antarctica: seasonal iron limitation in Antarctic shelf waters. *Journal of Geophysical Research* 105 (C5), 11 321-11 336.
- Sievers, H.A., Nowlin, W.D., **1984**. The stratification and water masses at Drake Passage. *Journal of Geophysical Research* 89 (NC6), 489-514.
- Sunda, W.G., Swift, D.G., Huntsman, S.A., **1991**. Low iron requirement for growth in oceanic phytoplankton. *Nature* 351 (6321), 55-57.
- Sunda, W.G., Huntsman, S.A., **1997**. Interrelated influence of iron, light and cell size on marine phytoplankton growth. *Nature* 390 (6658), 389-392.
- Sunda, W.G., **2001**. Bioavailability and Bioaccumulation of Iron in the Sea. Chapter 3 in: Turner, D.R., Hunter, K.A. (eds.). *The Biogeochemistry of Iron in Seawater*. Wiley and sons. 7, 41-84

## References

- Takata H., Kuma, K., Isoda, Y., Otosaka, S., Senju, T., Minagawa, M., **2008**. Iron in the Japan Sea and its implications for the physical processes in deep water. *Geophysical Research Letters* 35, L02606.
- Tani, H., Nishioka, J., Kuma, K., Takata, H., Yamashita, Y., Tanque, Y., Tanoue, E., Midorikawa, T., **2003**. Iron(III) hydroxide solubility and humic-type fluorescent organic matter in the deep water column of the Okhotsk Sea and the northwestern North Pacific Ocean. *Deep-Sea Research Part I* 50, 1063-1078.
- Taylor, S.R., **1964**. Abundance of chemical elements in the continental crust: a new table. *Geochimica et Cosmochimica Acta* 28 (8), 1273-1285.
- Tomas, D.N., Kennedy, H., Kattner, G., Gerdes, D., Gough, C., Dieckmann, G.S., **2001**. Biogeochemistry of platelet ice: its influence on particle flux under fast ice in the Weddell Sea, Antarctica. *Polar Biology* 24 (7), 486-496
- Tomczak, M., Godfrey, J.S., 2001. Regional oceanography: An introduction. First Edition (1994), Pergamon Edition.  
<http://www.cmima.csic.es/mirror/mattom/regoc/pdfversion.html>.
- Thuróczy, C.-E., Boye, B., Losno, R., **2010a**. Dissolution of cobalt and zinc from natural and anthropogenic dusts in seawater. *Biogeosciences* 7 (6), 1927-1936.
- Thuróczy, C.-E., Gerringsa, L.J.A., Klunder, M.B., Middag, R., Laan, P., Timmermans, K.R., De Baar, H.J.W., **2010b**. Speciation of Fe in the Eastern North Atlantic Ocean. *Deep-Sea Research Part I* 57 (11), 1444-1453.
- Thuróczy, C.-E., Gerringsa, L.J.A., Klunder, M.B., Laan, P., De Baar, H.J.W., **2011a**. Observation of consistent trends in the organic complexation of dissolved iron in the Atlantic sector of the Southern Ocean. *Deep-Sea Research Part II*, in press.
- Thuróczy, C.-E., Gerringsa, L.J.A., Klunder, M.B., Laan, P., Le Guittion, M., De Baar, H.J.W., **2011b**. Distinct trends in the speciation of iron between the shelf seas and the deep basins of the Arctic Ocean. *Journal of Geophysical Research-Oceans*, in press.
- Thuróczy, C.-E., Alderkamp, A.-C., Laan, P., Gerringsa, L.J.A., M.M. Mills, G.L. Van Dijken, 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). **Submitted** to Deep-Sea Research Part II.
- Timmermans, K.R., Gledhill, M., Nolting, R.F., Veldhuis, M.J.W., De Baar, H.J.W., Van Den Berg, C.M.G., **1998**. Responses of marine phytoplankton in

## References

- iron enrichment experiments in the northern North Sea and northeast Atlantic Ocean. *Marine Chemistry* 61 (3-4), 229-242.
- Timmermans, K.R., Davey, M.S., Van Der Wagt, B., Snoek, J., Geider, R.J., Veldhuis, M.J.W., Gerringa, L.J.A., De Baar, H.J.W., **2001**. Co-limitation by iron and light of *Chaetoceros brevis*, *C. dichaeta* and *C. calcitrans* Bacillariophyceae. *Marine Ecology Progress Series* 217, 287-297.
- Timmermans, K.R., Van Der Wagt, B., De Baar, H.J.W., **2004**. Growth rates, half-saturation constants, and silicate, nitrate, and phosphate depletion in relation to iron availability of four large, open-ocean diatoms from the Southern Ocean. *Limnology and Oceanography* 49 (6), 2141-2151.
- Timmermans, K.R., Van Der Wagt, B., Veldhuis, M.J.W., Maatman, A., De Baar, H.J.W., **2005**. Physiological responses of three species of marine pico-phytoplankton to ammonium, phosphate, iron and light limitation. *Journal of Sea Research* 53 (1-2), 109-120.
- Tortell, P.D., Maldonado, M.T., Price, N.M., **1996**. The role of heterotrophic bacteria in iron-limited ocean ecosystems. *Nature* 383, (6598) 330-332.
- Tortell, P.D., Maldonado, M.T., Granger, J., Price, N.M., **1999**. Marine bacteria and biogeochemical cycling of iron in the oceans. *FEMS Microbiology and Ecology* 29 (1), 1-11.
- Turner, D.R., Hunter, K.A., De Baar, H.J.W., **2001**. Introduction in: Turner, D.R., Hunter, K.A. (eds.). *The Biogeochemistry of Iron in Seawater*. Wiley and sons. 7, 41-84.
- Turoczy, N.J., Sherwood, J.E., **1997**. Modification of the Van Den Berg/Ruzic method for the investigation of complexation parameters of natural waters. *Analytica Chimica Acta* 354 (1-3), 15-21.
- Ussher, S.J., Achterberg, E.P., Worsfold, P.J., **2004**. Marine Biogeochemistry of Iron. *Environmental Chemistry* 1, 67-80.
- Ussher, S.J., Worsfold, P.J., Achterberg, E.P., Laës, A., Blain, S., Laan, P., De Baar, H.J.W., **2007**. Distribution and redox speciation of dissolved iron on the European continental margin. *Limnology and Oceanography* 52 (6), 2530-2539.
- Van Aken, H.M., **2001**. The hydrography of the mid-latitude Northeast Atlantic Ocean-Part III: the subducted thermocline water mass. *Deep-Sea Research Part I* 48 (1), 237-267.

## References

- Van Der Merwe, P., Lannuzel, D., Mancuso Nichols, C.A., Meiners, K., Heil, P., Norman, L., Thomas, D.N., Bowie, A.R., **2009**. Biogeochemical observations during the winter-spring transition in East Antarctic sea ice: Evidence of iron and exopolysaccharide controls. *Marine Chemistry* 115 (3-4), 163-175.
- Van Haren, H., Mills, D.K., Wetsteyn, L.P.M.J., **1998**. Detailed observations of the phytoplankton spring bloom in the stratifying central North Sea. *Journal of Marine Research* 56 (3), 655-680.
- Van Leeuwen, H.P., Jansen, S., **2005**. Dynamic aspects of metal speciation by competitive ligand exchange–adsorptive stripping voltammetry (CLE–AdSV). *Journal of Electroanalytical Chemistry* 579, 337–342
- Van Leeuwen, H.P., Raewyn, M.T., **2005**. Kinetic Limitations in Measuring Stabilities of Metal Complexes by Competitive Ligand Exchange-Adsorptive Stripping Voltammetry (CLE-AdSV). *Environmental Science and Technology* 39 (18), 7217-7225.
- Verdugo, P., Alldredge, A.L., Azam, F., Kirchman, D.L., Passow, U., Santschi, P.H., **2004**. The oceanic gel phase: a bridge in the DOM-POM continuum. *Marine Chemistry* 92, 67-85.
- Völker, C., Wolf-Gladrow, D.A., **1999**. Physical limits on iron uptake mediated by siderophores or surface reductases. *Marine Chemistry* 65 (3-4), 227-244.
- Vraspir, J.M., Butler, A., **2009**. Chemistry of marine ligands and siderophores. *Annual Review of Marine Science* 1, 43-63.
- Wells, M.L., Goldberg, E.D., **1993**. Colloid aggregation in seawater. *Marine Chemistry* 41 (4), 353-358.
- Wells, M.L., Goldberg, E.D., **1994**. The distribution of colloids in the North Atlantic and Southern Oceans. *Limnology and Oceanography* 39 (2), 286-302.
- Wells, M.L., Smith, G.J., Bruland, K.W., **2000**. The distribution of colloidal and particulate bioactive metals in Narragansett Bay, RI. *Marine Chemistry* 71 (1-2), 143-163.
- Whitworth III, T., Nolwin Jr., W.D., **1987**. Water masses and Currents of the Southern Ocean at the Greenwich Meridian. *Journal of Geophysical Research* 92 (C6), 6462-6476.
- Wilhelm, S.W., Trick, C.G., **1994**. Iron-limited growth of cyanobacteria: multiple siderophore production is a common response. *Limnology and Oceanography* 39 (8), 1979-1984.

## References

- Wilhelm, S.W., **1995**. Ecology of iron-limited cyanobacteria: a review of physiological responses and implications for aquatic systems. *Aquatic Microbiology and Ecology* 9, 295-303.
- Wilhelm, S.W., Maxwell, D.P., Trick, C.G., **1996**. Response of the cyanobacterium *Synechococcus* PCC 7002 to iron-limitation: growth, iron requirements and siderophore production. *Limnology and Oceanography* 41, 89-97.
- Wilhelm, S.W., MacAuley, K., Trick, C.G., **1997**. Evidence for the importance of catechol-type siderophores in the iron-limited growth of a cyanobacterium. *Limnology and Oceanography* 43, 992-997.
- Witter, A.E., Luther III, G.W., **1998**. Variation in Fe-organic complexation with depth in the Northwestern Atlantic Ocean as determined using a kinetic approach. *Marine Chemistry* 62 (3-4), 241-258.
- Witter, A.E., Hutchins, D.A., Butler, A., Luther III, G.W., **2000**. Determination of conditional stability constants and kinetic constants for strong model Fe-binding ligands in seawater. *Marine Chemistry* 69 (1-2), 1-17.
- Wu, J., Luther III, G.W., **1995**. Complexation of Fe(III) by natural organic ligands in the Northwest Atlantic Ocean by a competitive ligand equilibration method and a kinetic approach. *Marine Chemistry* 50 (1-4), 159-177.
- Wu, J., Boyle, E., Sunda, W., Wen, L.-S., **2001**. Soluble and colloidal iron in the oligotrophic north Atlantic and north Pacific. *Science* 293 (5531), 847-849.
- Yamamoto-Kawai, M., Tanaka, N., Pivovarov, S., **2005**. Freshwater and brine behaviors in the Arctic Ocean deduced from historical data of d<sub>18</sub>O and alkalinity (1929-2002 A.D.). *Journal of Geophysical Research* 110 (C10), C10003.

