



UvA-DARE (Digital Academic Repository)

Linking microbial community structure to biogeochemical function in coastal marine sediments: Stable isotope probing combined with magnetic bead capture

Miyatake, T.

Publication date
2011

[Link to publication](#)

Citation for published version (APA):

Miyatake, T. (2011). *Linking microbial community structure to biogeochemical function in coastal marine sediments: Stable isotope probing combined with magnetic bead capture*. [Thesis, externally prepared, Universiteit van Amsterdam].

General rights

It is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), other than for strictly personal, individual use, unless the work is under an open content license (like Creative Commons).

Disclaimer/Complaints regulations

If you believe that digital publication of certain material infringes any of your rights or (privacy) interests, please let the Library know, stating your reasons. In case of a legitimate complaint, the Library will make the material inaccessible and/or remove it from the website. Please Ask the Library: <https://uba.uva.nl/en/contact>, or a letter to: Library of the University of Amsterdam, Secretariat, Singel 425, 1012 WP Amsterdam, The Netherlands. You will be contacted as soon as possible.

References

- Acinas SG, Sarma-Rupavtarm R, Klepac-Ceraj V, Polz MF (2005). PCR-induced sequence artifacts and bias: insights from comparison of two 16S rRNA clone libraries constructed from the same sample. *Appl Environ Microbiol* **71**: 8966-8969.
- Aida M, Kanemori M, Kubota N, Matada M, Sasayama Y, Fukumori Y (2008). Distribution and population of free-living cells related to endosymbiont harbored in *Oligobrachia mashikoi* (a Siboglinid Polychaete) inhabiting Tsukumo Bay. *Microbes Environ* **23**: 81-88.
- Amann RI, Binder BJ, Olson RJ, Chisholm SW, Devereux R, Stahl DA (1990). Combination of 16S rRNA-targeted oligonucleotide probes with flow cytometry for analyzing mixed microbial populations. *Appl Environ Microbiol* **56**: 1919-1925.
- Arakawa S, Sato T, Yoshida Y, Usami R, Kato C (2006). Comparison of the microbial diversity in cold-seep sediments from different depths in the Nankai Trough. *J Gen Appl Microbiol* **52**: 47-54.
- Bühning SI, Elvert M, Witte U (2005). The microbial community structure of different permeable sandy sediments characterized by the investigation of bacterial fatty acids and fluorescence *in situ* hybridization. *Environ Microbiol* **7**: 281-293.
- Bach HJ, Hartmann A, Trevors JT, Munch JC (1999). Magnetic capture-hybridization method for purification and probing of mRNA for neutral protease of *Bacillus cereus*. *J Microbiol Methods* **37**: 187-192.
- Bagarinao T (1992). Sulfide as an environmental-factor and toxicant - tolerance and adaptations in aquatic organisms. *Aquat Toxicol* **24**: 21-62.
- Bak F, Pfennig N (1987). Chemolithotrophic growth of *Desulfovibrio sulfodismutans* sp. nov. by disproportionation of inorganic sulfur compounds. *Arch Microbiol* **147**: 184-189.
- Bardgett RD, Freeman C, Ostle NJ (2008). Microbial contributions to climate change through carbon cycle feedbacks. *ISME J* **2**: 805-814.
- Behrens S, Losekann T, Pett-Ridge J, Weber PK, Ng W-O, Stevenson BS *et al* (2008). Linking microbial phylogeny to metabolic activity at the single-cell level by using enhanced element labeling-catalyzed reporter deposition fluorescence *in situ* hybridization (EL-FISH) and NanoSIMS. *Appl Environ Microbiol* **74**: 3143-3150.
- Bellinger BJ, Underwood GJC, Ziegler SE, Gretz MR (2009). Significance of diatom-derived polymers in carbon flow dynamics within estuarine biofilms determined through isotopic enrichment. *Aquat Microb Ecol* **55**: 169-187.
- Berner RA (1982). Burial of organic carbon and pyrite sulfur in the modern ocean: Its geochemical and environmental significance. *Am J Sci* **282**: 451-473.
- Boschker HTS, Nold SC, Wellsbury P, Bos D, de Graaf W, Pel R *et al* (1998). Direct linking of microbial populations to specific biogeochemical processes by ¹³C-labelling of biomarkers. *Nature* **392**: 801-805.

- Boschker HTS, de Brouwer JFC, Cappenberg TE (1999). The contribution of macrophyte-derived organic matter to microbial biomass in salt-marsh sediments: Stable carbon isotope analysis of microbial biomarkers. *Limnol Oceanogr* **44**: 309-319.
- Boschker HTS, Middelburg JJ (2002). Stable isotopes and biomarkers in microbial ecology. *FEMS Microbiol Ecol* **40**: 85-95.
- Boschker HTS (2004). Linking microbial community structure and functioning: stable isotope (^{13}C) labeling in combination with PLFA analysis. In: Kowalchuk GA, F.J. de Bruijn, I.M. Head, A.D. Akkermans and J.D. van Elsas (ed). *Molecular Microbial Ecology Manual II*. Kluwer Academic Publishers: Dordrecht, The Netherlands. pp 1673-1688.
- Boschker HTS, Moerdijk-Poortvliet TCW, van Breugel P, Houtekamer M, Middelburg JJ (2008). A versatile method for stable carbon isotope analysis of carbohydrates by high-performance liquid chromatography/isotope ratio mass spectrometry. *Rapid Commun Mass Spectrom* **22**: 3902-3908.
- Boschker HTS, Moerdijk-Poortvliet T, Moodley L (2010). Chemoautotrophy in costal marine sediments. *unpublished*.
- Bowman JP, McCammon SA, Nichols DS, Skerratt JH, Rea SM, Nichols PD *et al* (1997). *Shewanella gelidimarina* sp. nov. and *Shewanella frigidimarina* sp. nov., Novel antarctic species with the ability to produce eicosapentaenoic acid (20:5 ω 3) and grow anaerobically by dissimilatory Fe(III) reduction. *Int J Syst Bacteriol* **47**: 1040-1047.
- Bowman JP, McCammon SA, Gibson JAE, Robertson L, Nichols PD (2003). Prokaryotic metabolic activity and community structure in Antarctic continental shelf sediments. *Appl Environ Microbiol* **69**: 2448-2462.
- Bowman JP, McCuaig RD (2003). Biodiversity, Community Structural Shifts, and Biogeography of Prokaryotes within Antarctic Continental Shelf Sediment. *Appl Environ Microbiol* **69**: 2463-2483.
- Braker G, Zhou J, Wu L, Devol AH, Tiedje JM (2000). Nitrite reductase genes (nirK and nirS) as functional markers to investigate diversity of denitrifying bacteria in Pacific Northwest marine sediment communities. *Appl Environ Microbiol* **66**: 2096-2104.
- Braker G, Ayala-del-Río HL, Devol AH, Fesefeldt A, Tiedje JM (2001). Community structure of denitrifiers, *Bacteria*, and *Archaea* along redox gradients in pacific northwest marine sediments by terminal restriction fragment length polymorphism analysis of amplified nitrite reductase (nirS) and 16S rRNA genes. *Appl Environ Microbiol* **67**: 1893-1901.
- Bright M, Bulgheresi S (2010). A complex journey: transmission of microbial symbionts. *Nat Rev Microbiol* **8**: 218-230.
- Brinch-Iversen J, King GM (1990). Effects of substrate concentration, growth state, and oxygen availability on relationships among bacterial carbon, nitrogen and phospholipid phosphorus content. *FEMS Microbiol Ecol* **74**: 345-355.
- Brune A, Frenzel P, Cypionka H (2000). Life at the oxic-anoxic interface: microbial activities and adaptations. *FEMS Microbiol Rev* **24**: 691-710.
- Canfield DE, Jørgensen BB, Fossing H, Glud R, Gundersen J, Ramsing NB *et al* (1993). Pathways of organic-carbon oxidation in 3 continental-margin sediments. *Marine Geology* **113**: 27-40.

- Canfield DE, Thamdrup B (1996). Fate of elemental sulfur in an intertidal sediment. *FEMS Microbiol Ecol* **19**: 95-103.
- Canfield DE, Kristensen E, Thamdrup B (2005). *Aquatic geomicrobiology*. Elsevier: Oxford, United Kingdom.
- Chapman PM, Wang FY, Germano JD, Batley G (2002). Pore water testing and analysis: the good, the bad, and the ugly. *Mar Pollut Bull* **44**: 359-366.
- Cline JD (1969). Spectrophotometric determination of hydrogen sulfide in natural waters. *Limnol Oceanogr* **14**: 454-458.
- Coffin RB, Velinsky DJ, Devereux R, Price WA, Cifuentes LA (1990). Stable carbon isotope analysis of nucleic acids to trace sources of dissolved substrates used by estuarine bacteria. *Appl Environ Microbiol* **56**: 2012-2020.
- Daims H, Bruhl A, Amann R, Schleifer KH, Wagner M (1999). The domain-specific probe EUB338 is insufficient for the detection of all Bacteria: Development and evaluation of a more comprehensive probe set. *Syst Appl Microbiol* **22**: 434-444.
- de Brouwer JFC, Stal LJ (2001). Short-term dynamics in microphytobenthos distribution and associated extracellular carbohydrates in surface sediments of an intertidal mudflat. *Mar Ecol Prog Ser* **218**: 33-44.
- Dhillon A, Teske A, Dillon J, Stahl DA, Sogin ML (2003). Molecular characterization of sulfate-reducing bacteria in the Guaymas Basin. *Appl Environ Microbiol* **69**: 2765-2772.
- Dijkman NA, Kromkamp JC (2006). Phospholipid-derived fatty acids as chemotaxonomic markers for phytoplankton: application for inferring phytoplankton composition. *Mar Ecol Prog Ser* **324**: 113-125.
- Distel DL, Felbeck H, Cavanaugh CM (1994). Evidence for phylogenetic congruence among sulfur-oxidizing chemoautotrophic bacterial endosymbionts and their bivalve hosts. *J Mol Evol* **38**: 533-542.
- Dowling NJE, Widdel F, White DC (1986). Phospholipid ester-linked fatty-acid biomarkers of acetate-oxidizing sulfate-reducers and other sulfide-forming bacteria. *J Gen Microbiol* **132**: 1815-1825.
- Drigo B, Pijl AS, Duyts H, Kielak A, Gamper HA, Houtekamer MJ *et al* (2010). Shifting carbon flow from roots into associated microbial communities in response to elevated atmospheric CO₂. *Proc Nat Acad Sci USA* **107**: 10938-10942.
- Dubilier N, Mülders C, Ferdelman T, de Beer D, Pernthaler A, Klein M *et al* (2001). Endosymbiotic sulphate-reducing and sulphide-oxidizing bacteria in an oligochaete worm. *Nature* **411**: 298-302.
- Duineveld BM, Kowalchuk GA, Keijzer A, van Elsas JD, van Veen JA (2001). Analysis of bacterial communities in the rhizosphere of chrysanthemum via denaturing gradient gel electrophoresis of PCR-amplified 16S rRNA as well as DNA fragments coding for 16S rRNA. *Appl Environ Microbiol* **67**: 172-178.
- Edgcomb VP, McDonald JH, Devereux R, Smith DW (1999). Estimation of bacterial cell numbers in humic acid-rich salt marsh sediments with probes directed to 16S ribosomal DNA. *Appl Environ Microbiol* **65**: 1516-1523.

- Edlund A, Hårdeman F, Jansson JK, Sjöling S (2008). Active bacterial community structure along vertical redox gradients in Baltic Sea sediment. *Environ Microbiol* **10**: 2051-2063.
- Enoksson V, Samuelsson MO (1987). Nitrification and dissimilatory ammonium production and their effects on nitrogen flux over the sediment-water interface in bioturbated coastal sediments. *Mar Ecol Prog Ser* **36**: 181-189.
- Evrard V, Cook PLM, Veuger B, Huettel M, Middelburg JJ (2008). Tracing carbon and nitrogen incorporation and pathways in the microbial community of a photic subtidal sand. *Aquat Microb Ecol* **53**: 257-269.
- Fegatella F, Lim J, Kjelleberg S, Cavicchioli R (1998). Implications of rRNA operon copy number and ribosome content in the marine oligotrophic ultramicrobacterium *Sphingomonas* sp. strain RB2256. *Appl Environ Microbiol* **64**: 4433-4438.
- Flårdh K, Cohen PS, Kjelleberg S (1992). Ribosomes exist in large excess over the apparent demand for protein synthesis during carbon starvation in marine *Vibrio* sp. strain CCUG 15956. *J Bacteriol* **174**: 6780-6788.
- Friedrich MW (2006). Stable-isotope probing of DNA: insights into the function of uncultivated microorganisms from isotopically labeled metagenomes. *Curr Opin Biotechnol* **17**: 59-66.
- Fuchs BM, Wallner G, Beisker W, Schwiippel I, Ludwig W, Amann R (1998). Flow cytometric analysis of the in situ accessibility of *Escherichia coli* 16S rRNA for fluorescently labeled oligonucleotide probes. *Appl Environ Microbiol* **64**: 4973-4982.
- Fuchs BM, Glöckner FO, Wulf J, Amann R (2000). Unlabeled helper oligonucleotides increase the in situ accessibility to 16S rRNA of fluorescently labeled oligonucleotide probes. *Appl Environ Microbiol* **66**: 3603-3607.
- Fuchs BM, Syutsubo K, Ludwig W, Amann R (2001). In situ accessibility of *Escherichia coli* 23S rRNA to fluorescently labeled oligonucleotide probes. *Appl Environ Microbiol* **67**: 961-968.
- Gentile G, Giuliano, D'Auria G, Smedile F, Azzaro M, De Domenico M *et al* (2006). Study of bacterial communities in Antarctic coastal waters by a combination of 16S rRNA and 16S rDNA sequencing. *Environ Microbiol* **8**: 2150-2161.
- Givskov M, Eberl L, Møller S, Poulsen LK, Molin S (1994). Responses to nutrient starvation in *Pseudomonas putida* KT2442: Analysis of general cross-protection, cell shape, and macromolecular content. *J Bacteriol* **176**: 7-14.
- Glaubitz S, Lueders T, Abraham WR, Jost G, Jürgens K, Labrenz M (2009). ¹³C-isotope analyses reveal that chemolithoautotrophic *Gamma*- and *Epsilon*proteobacteria feed a microbial food web in a pelagic redoxcline of the central Baltic Sea. *Environ Microbiol* **11**: 326-337.
- Glud RN (2008). Oxygen dynamics of marine sediments. *Mar Biol Res* **4**: 243-289.
- Goto N, Mitamura O, Terai H (2001). Biodegradation of photosynthetically produced extracellular organic carbon from intertidal benthic algae. *J Exp Mar Biol Ecol* **257**: 73-86.

- Hanlon ARM, Bellinger B, Haynes K, Xiao G, Hofmann TA, Gretz MR *et al* (2006). Dynamics of extracellular polymeric substance (EPS) production and loss in an estuarine, diatom-dominated, microalgal biofilm over a tidal emersion-immersion period. *Limnol Oceanogr* **51**: 79-93.
- Haynes K, Hofmann TA, Smith CJ, Ball AS, Underwood GJC, Osborn AM (2007). Diatom-derived carbohydrates as factors affecting bacterial community composition in estuarine sediments. *Appl Environ Microbiol* **73**: 6112-6124.
- Hoehler TM, Alperin MJ, Albert DB, Martens CS (1998). Thermodynamic control on hydrogen concentrations in anoxic sediments. *Geochim Cosmochim Acta* **62**: 1745-1756.
- Huang WE, Stoecker K, Griffiths R, Newbold L, Daims H, Whiteley AS *et al* (2007). Raman-FISH: combining stable-isotope Raman spectroscopy and fluorescence in situ hybridization for the single cell analysis of identity and function. *Environ Microbiol* **9**: 1878-1889.
- Hunt DE, Klepac-Ceraj V, Acinas SG, Gautier C, Bertilsson S, Polz MF (2006). Evaluation of 23S rRNA PCR primers for use in phylogenetic studies of bacterial diversity. *Appl Environ Microbiol* **72**: 2221-2225.
- Hunter EM, Mills HJ, Kostka JE (2006). Microbial community diversity associated with carbon and nitrogen cycling in permeable shelf sediments. *Appl Environ Microbiol* **72**: 5689-5701.
- Ivanova EP, Sawabe T, Gorshkova NM, Svetashev VI, Mikhailov VV, Nicolau DV *et al* (2001). *Shewanella japonica* sp. nov. *Int J Syst Evol Microbiol* **51**: 1027-1033.
- Jørgensen BB (1978). Comparison of methods for the quantification of bacterial sulfate reduction in coastal marine sediments .1. Measurement with radiotracer techniques. *Geomicrobiol J* **1**: 11-27.
- Jørgensen BB (1982). Mineralization of organic matter in the sea bed - the role of sulphate reduction. *Nature* **296**: 643-645.
- Jørgensen BB, Bak F (1991). Pathways and microbiology of thiosulfate transformations and sulfate reduction in a marine sediment (Kattegat, Denmark). *Appl Environ Microbiol* **57**: 847-856.
- Jørgensen BB, Nelson DC (2004). Sulfide oxidation in marine sediments: Geochemistry meets microbiology. In: Amend JP, Edwards KJ, Lyons TW (eds). *Sulfur Biogeochemistry - Past and Present*. The Geological Society of America: Boulder, USA. pp 63-81.
- Jørgensen BB (2006). Bacteria and Marine Biogeochemistry. In: Schulz HD, Zabel M (eds). *Marine Geochemistry*, 2nd revised, updated and extended edition edn. Springer Berlin Heidelberg: Berlin. pp 169-206.
- Jannasch HW, Wirsen CO (1979). Chemo-synthetic primary production at east Pacific sea-floor spreading centers. *Bioscience* **29**: 592-598.
- Jannasch HW, Nelson DC, Wirsen CO (1989). Massive natural occurrence of unusually large bacteria (*Beggiatoa* sp.) at a hydrothermal deep-sea vent site. *Nature* **342**: 834-836.
- Janssen PH, Schuhmann A, Bak F, Liesack W (1996). Disproportionation of inorganic sulfur compounds by the sulfate-reducing bacterium *Desulfocapsa thiozymogenes* gen. nov., sp. nov. *Arch Microbiol* **166**: 184-192.

- Jost G, Zubkov MV, Yakushev E, Labrenz M, Jürgens K (2008). High abundance and dark CO₂ fixation of chemolithoautotrophic prokaryotes in anoxic waters of the Baltic Sea. *Limnol Oceanogr* **53**: 14-22.
- Kemp PF, Aller JY (2004). Bacterial diversity in aquatic and other environments: what 16S rDNA libraries can tell us. *FEMS Microbiol Ecol* **47**: 161-177.
- Kerger BD, Nichols PD, Antworth CP, Sand W, Bock E, Cox JC *et al* (1986). Signature fatty-acids in the polar lipids of acid-producing *Thiobacillus* spp.: Methoxy, cyclopropyl, alpha-hydroxy-cyclopropyl and normal monoenoic fatty-acids. *FEMS Microbiol Ecol* **38**: 67-77.
- Kerkhof L, Kemp P (1999). Small ribosomal RNA content in marine Proteobacteria during non-steady-state growth. *FEMS Microbiol Ecol* **30**: 253-260.
- Kester DR, Duedall IW, Connors DN, Pytkowicz RM (1967). Preparation of artificial seawater. *Limnol Oceanogr* **12**: 176-179.
- Klepac-Ceraj V, Bahr M, Crump BC, Teske AP, Hobbie JE, Polz MF (2004). High overall diversity and dominance of microdiverse relationships in salt marsh sulphate-reducing bacteria. *Environ Microbiol* **6**: 686-698.
- Knief C, Altendorf K, Lipski A (2003). Linking autotrophic activity in environmental samples with specific bacterial taxa by detection of ¹³C-labelled fatty acids. *Environ Microbiol* **5**: 1155-1167.
- Krumbock M, Conrad R (1991). Metabolism of position-labeled glucose in anoxic methanogenic paddy soil and lake sediment. *FEMS Microbiol Ecol* **85**: 247-256.
- Krummen M, Hilkert AW, Juchelka D, Duhr A, Schluter HJ, Pesch R (2004). A new concept for isotope ratio monitoring liquid chromatography/mass spectrometry. *Rapid Commun Mass Spectrom* **18**: 2260-2266.
- Lücker S, Steger D, Kjeldsen KU, MacGregor BJ, Wagner M, Loy A (2007). Improved 16S rRNA-targeted probe set for analysis of sulfate-reducing bacteria by fluorescence in situ hybridization. *J Microbiol Methods* **69**: 523-528.
- Lewin J, Hellebust JA (1976). Heterotrophic nutrition of the marine pennate diatom *Nitzschia angularis* var. *affinis*. *Mar Biol* **36**: 313-320.
- Liesack W, Finster K (1994). Phylogenetic analysis of five strains of gram-negative, obligately anaerobic, sulfur-reducing bacteria and description of *Desulfuromusa* gen. nov., including *Desulfuromusa kysingii* sp. nov., *Desulfuromusa bakii* sp. nov., and *Desulfuromusa succinoxidans* sp. nov. *Int J Syst Bacteriol* **44**: 753-758.
- Lipski A, Spieck E, Makolla A, Altendorf K (2001). Fatty acid profiles of nitrite-oxidizing bacteria reflect their phylogenetic heterogeneity. *Syst Appl Microbiol* **24**: 377-384.
- Lovley DR (1991). Dissimilatory Fe(III) and Mn(IV) reduction. *Microbiol Rev* **55**: 259-287.
- Loy A, Lehner A, Lee N, Adamczyk J, Meier H, Ernst J *et al* (2002). Oligonucleotide microarray for 16S rRNA gene-based detection of all recognized lineages of sulfate-reducing prokaryotes in the environment. *Appl Environ Microbiol* **68**: 5064-5081.

- Ludwig W, Strunk O, Westram R, Richter L, Meier H, Yadhukumar *et al* (2004). ARB: a software environment for sequence data. *Nucl Acids Res* **32**: 1363-1371.
- Macalady JL, Lyon EH, Koffman B, Albertson LK, Meyer K, Galdenzi S *et al* (2006). Dominant microbial populations in limestone-corroding stream biofilms, Frasassi cave system, Italy. *Appl Environ Microbiol* **72**: 5596-5609.
- MacGregor BJ, Brüchert V, Fleischer S, Amann R (2002). Isolation of small-subunit rRNA for stable isotopic characterization. *Environ Microbiol* **4**: 451-464.
- MacGregor BJ, Boschker HTS, Amann R (2006). Comparison of rRNA and polar-lipid-derived fatty acid biomarkers for assessment of ¹³C-substrate incorporation by microorganisms in marine sediments. *Appl Environ Microbiol* **72**: 5246-5253.
- MacIntyre HL, Geider RJ, Miller DC (1996). Microphytobenthos: The ecological role of the "secret garden" of unvegetated, shallow-water marine habitats . I. Distribution, abundance and primary production. *Estuaries* **19**: 186-201.
- Manefield M, Whiteley AS, Griffiths RI, Bailey MJ (2002). RNA stable isotope probing, a novel means of linking microbial community function to phylogeny. *Appl Environ Microbiol* **68**: 5367-5373.
- Manefield M, Whiteley AS, Bailey MJ (2004). What can stable isotope probing do for bioremediation? *Int Biodeterior Biodegrad* **54**: 163-166.
- Manz W, Amann R, Ludwig W, Wagner M, Schleifer KH (1992). Phylogenetic oligodeoxynucleotide probes for the major subclasses of *Proteobacteria* - problems and solutions. *Syst Appl Microbiol* **15**: 593-600.
- Manz W, Eisenbrecher M, Neu TR, Szewzyk U (1998). Abundance and spatial organization of gram-negative sulfate-reducing bacteria in activated sludge investigated by in situ probing with specific 16S rRNA targeted oligonucleotides. *FEMS Microbiol Ecol* **25**: 43-61.
- Martinez RJ, Mills HJ, Story S, Sobecky PA (2006). Prokaryotic diversity and metabolically active microbial populations in sediments from an active mud volcano in the Gulf of Mexico. *Environ Microbiol* **8**: 1783-1796.
- Mastrangeli R, Micangeli E, Donini S (1996). Cloning of murine LAG-3 by magnetic bead bound homologous probes and PCR (GENE-CAPTURE PCR). *Anal Biochem* **241**: 93-102.
- Mengoni A, Tatti E, Decorosi F, Viti C, Bazzicalupo M, Giovannetti L (2005). Comparison of 16S rRNA and 16S rDNA T-RFLP approaches to study bacterial communities in soil microcosms treated with chromate as perturbing agent. *Microb Ecol* **50**: 375-384.
- Meysman FJR, Middelburg JJ, Heip CHR (2006). Bioturbation: a fresh look at Darwin's last idea. *Trends Ecol Evol* **21**: 688-695.
- Middelburg JJ, Barranguet C, Boschker HTS, Herman PMJ, Moens T, Heip CHR (2000). The fate of intertidal microphytobenthos carbon: An in situ ¹³C-labeling study. *Limnol Oceanogr* **45**: 1224-1234.
- Middelburg JJ, Soetaert K (2005). The role of sediments in shelf ecosystem dynamics. In: Robinson AR, Brink KH (eds). *The global coastal ocean. Multiscale interdisciplinary processes. The sea: ideas*

and observations on progress in the study of the seas. Harvard University Press: Cambridge. pp 353-374.

Mills HJ, Martinez RJ, Story S, Sobecky PA (2005). Characterization of microbial community structure in Gulf of Mexico gas hydrates: Comparative analysis of DNA- and RNA-derived clone libraries. *Appl Environ Microbiol* **71**: 3235-3247.

Miyajima T, Yamada Y, Hanba YT, Yoshii K, Koitabashi T, Wada E (1995). Determining the stable isotope ratio of total dissolved inorganic carbon in lakewater by GC/C/IRMS. *Limnol Oceanogr* **40**: 994-1000.

Miyatake T, MacGregor BJ, Boschker HTS (2009). Linking microbial community function to phylogeny of sulfate-reducing *Deltaproteobacteria* in marine sediments by combining stable isotope probing with magnetic-bead capture hybridization of 16S rRNA. *Appl Environ Microbiol* **75**: 4927-4935.

Miyatake T, MacGregor BJ, Boschker HTS (2010). Linking microbial community structure and function in marine intertidal sediment by stable isotope probing combined with magnetic bead capture hybridization. *unpublished*.

Moeseneder MM, Arrieta JM, Herndl GJ (2005). A comparison of DNA- and RNA-based clone libraries from the same marine bacterioplankton community. *FEMS Microbiol Ecol* **51**: 341-352.

Moodley L, Boschker HTS, Middelburg JJ, Pel R, Herman PMJ, de Deckere E *et al* (2000). Ecological significance of benthic foraminifera: ¹³C labelling experiments. *Mar Ecol Prog Ser* **202**: 289-295.

Musat N, Halm H, Winterholler B, Hoppe P, Peduzzi S, Hillion F *et al* (2008). A single-cell view on the ecophysiology of anaerobic phototrophic bacteria. *Proc Nat Acad Sci USA* **105**: 17861-17866.

Musmann M, Ishii K, Rabus R, Amann R (2005). Diversity and vertical distribution of cultured and uncultured Deltaproteobacteria in an intertidal mud flat of the Wadden Sea. *Environ Microbiol* **7**: 405-418.

Neef A, Amann R, Schlesner H, Schleifer KH (1998). Monitoring a widespread bacterial group: in situ detection of planctomycetes with 16S rRNA-targeted probes. *Microbiology* **144**: 3257-3266.

Nercessian O, Fouquet Y, Pierre C, Prieur D, Jeanthon C (2005). Diversity of *Bacteria* and *Archaea* associated with a carbonate-rich metalliferous sediment sample from the Rainbow vent field on the Mid-Atlantic Ridge. *Environ Microbiol* **7**: 698-714.

Neufeld JD, Dumont MG, Vohra J, Murrell JC (2007a). Methodological considerations for the use of stable isotope probing in microbial ecology. *Microb Ecol* **53**: 435-442.

Neufeld JD, Wagner M, Murrell JC (2007b). Who eats what, where and when? Isotope-labelling experiments are coming of age. *ISME J* **1**: 103-110.

Nogales B, Moore ERB, Abraham W-R, Timmis KN (1999). Identification of the metabolically active members of a bacterial community in a polychlorinated biphenyl-polluted moorland soil. *Environ Microbiol* **1**: 199-212.

- Nogales B, Moore ERB, Llobet-Brossa E, Rossello-Mora R, Amann R, Timmis KN (2001). Combined use of 16S ribosomal DNA and 16S rRNA to study the bacterial community of polychlorinated biphenyl-polluted soil. *Appl Environ Microbiol* **67**: 1874-1884.
- Novelli PC, Michelson AR, Scranton MI, Banta GT, Hobbie JE, Howarth RW (1988). Hydrogen and acetate cycling in two sulfate-reducing sediments: Buzzards Bay and Town Cove, Mass. *Geochim Cosmochim Acta* **52**: 2477-2486.
- Oenema O (1990). Sulfate reduction in fine-grained sediments in the Eastern Scheldt, southwest Netherlands. *Biogeochemistry* **9**: 53-74.
- Ott J, Bright M, Bulgheresi S (2004). Symbioses between marine nematodes and sulfur-oxidizing chemoautotrophic bacteria. *Symbiosis* **36**: 103-126.
- Oude Elferink SJWH, Boschker HTS, Stams AJM (1998). Identification of sulfate reducers and *Syntrophobacter* sp. in anaerobic granular sludge by fatty-acid biomarkers and 16S rRNA probing. *Geomicrobiol J* **15**: 3-17.
- Paterson DM, Black KS (1999). Water flow, sediment dynamics and benthic biology. *Adv Ecol Res* **29**: 155-193.
- Pearson A, Kraunz KS, Sessions AL, Dekas AE, Leavitt WD, Edwards KJ (2008). Quantifying microbial utilization of petroleum hydrocarbons in salt marsh sediments by using the ¹³C content of bacterial rRNA. *Appl Environ Microbiol* **74**: 1157-1166.
- Purdy KJ, Nedwell DB, Embley TM, Takii S (1997). Use of 16S rRNA-targeted oligonucleotide probes to investigate the occurrence and selection of sulfate-reducing bacteria in response to nutrient addition to sediment slurry microcosms from a Japanese estuary. *FEMS Microbiol Ecol* **24**: 221-234.
- Qiu XY, Wu LY, Huang HS, McDonel PE, Palumbo AV, Tiedje JM *et al* (2001). Evaluation of PCR-generated chimeras: Mutations, and heteroduplexes with 16S rRNA gene-based cloning. *Appl Environ Microbiol* **67**: 880-887.
- Rabus R, Hansen TA, Widdel F (2006). Dissimilatory sulfate- and sulfur-reducing prokaryotes. In: Dworkin M, Falkow S, Rosenberg E, Schleifer KH, Stackebrandt E (eds). *Prokaryotes*. Springer Science Online: Heidelberg, Germany. pp 659-768.
- Radajewski S, Ineson P, Parekh NR, Murrell JC (2000). Stable-isotope probing as a tool in microbial ecology. *Nature* **403**: 646-649.
- Ratledge C, Wilkinson SG (1988). *Microbial Lipids*, vol. 1. Academic Press: London.
- Ravenschlag K, Sahn K, Knoblauch C, Jørgensen BB, Amann R (2000). Community structure, cellular rRNA content, and activity of sulfate-reducing bacteria in marine arctic sediments. *Appl Environ Microbiol* **66**: 3592-3602.
- Ravenschlag K, Sahn K, Amann R (2001). Quantitative Molecular Analysis of the Microbial Community in Marine Arctic Sediments (Svalbard). *Appl Environ Microbiol* **67**: 387-395.
- Rosset R, Julien J, Monier R (1966). Ribonucleic acid composition of bacteria as a function of growth rate. *J Mol Biol* **18**: 308-320.

- Rusch A, Huettel M, Reimers CE, Taghon GL, Fuller CM (2003). Activity and distribution of bacterial populations in Middle Atlantic Bight shelf sands. *FEMS Microbiol Ecol* **44**: 89-100.
- Sørensen J, Christensen D, Jørgensen BB (1981). Volatile fatty acids and hydrogen as substrates for sulfate-reducing bacteria in anaerobic marine sediment. *Appl Environ Microbiol* **42**: 5-11.
- Sahm K, MacGregor BJ, Jørgensen BB, Stahl DA (1999). Sulphate reduction and vertical distribution of sulphate-reducing bacteria quantified by rRNA slot-blot hybridization in a coastal marine sediment. *Environ Microbiol* **1**: 65-74.
- Schönhuber W, Zarda B, Eix S, Rippka R, Herdman M, Ludwig W *et al* (1999). In situ identification of cyanobacteria with horseradish peroxidase-labeled, rRNA-targeted oligonucleotide probes. *Appl Environ Microbiol* **65**: 1259-1267.
- Scheffer M, Rinaldi S, Huisman J, Weissing FJ (2003). Why plankton communities have no equilibrium: solutions to the paradox. *Hydrobiologia* **491**: 9-18.
- Schippers A, Jørgensen BB (2001). Oxidation of pyrite and iron sulfide by manganese dioxide in marine sediments. *Geochim Cosmochim Acta* **65**: 915-922.
- Sessions AL, Sylva SP, Hayes JM (2005). Moving-wire device for carbon isotopic analyses of nanogram quantities of nonvolatile organic carbon. *Anal Chem* **77**: 6519-6527.
- Severin I, Stal LJ (2010). NifH expression by five groups of phototrophs compared with nitrogenase activity in coastal microbial mats. *FEMS Microbiol Ecol* **73**: 55-67.
- Sinninghe Damste JS, Rijpstra WIC, Geenevasen JAJ, Strous M, Jetten MSM (2005). Structural identification of ladderane and other membrane lipids of planctomycetes capable of anaerobic ammonium oxidation (anammox). *FEBS J* **272**: 4270-4283.
- Sintes E, Herndl GJ (2006). Quantifying substrate uptake by individual cells of marine bacterioplankton by catalyzed reporter deposition fluorescence in situ hybridization combined with microautoradiography. *Appl Environ Microbiol* **72**: 7022-7028.
- Smith AJ (1982). Modes of cyanobacterial carbon metabolism. In: Carr NG, Whitton BA (eds). *The Biology of Cyanobacteria*. Blackwell Scientific Publications: Oxford, UK.
- Smith DJ, Underwood GJC (1998). Exopolymer production by intertidal epipellic diatoms. *Limnol Oceanogr* **43**: 1578-1591.
- Smith DJ, Underwood GJC (2000). The production of extracellular carbohydrates by estuarine benthic diatoms: The effects of growth phase and light and dark treatment. *J Phycol* **36**: 321-333.
- Soetaert K, Herman PMJ, Middelburg JJ (1996). A model of early diagenetic processes from the shelf to abyssal depths. *Geochim Cosmochim Acta* **60**: 1019-1040.
- Stahl DA, Flesher B, Mansfield HR, Montgomery L (1988). Use of phylogenetically based hybridization probes for studies of ruminal microbial ecology. *Appl Environ Microbiol* **54**: 1079-1084.
- Stal LJ, Moezelaar R (1997). Fermentation in cyanobacteria. *FEMS Microbiol Rev* **21**: 179-211.

- Strittmatter AW, Liesegang H, Rabus R, Decker I, Amann J, Andres S *et al* (2009). Genome sequence of *Desulfobacterium autotrophicum* HRM2, a marine sulfate reducer oxidizing organic carbon completely to carbon dioxide. *Environ Microbiol* **11**: 1038-1055.
- Sundh I (1992). Biochemical composition of dissolved organic carbon derived from phytoplankton and used by heterotrophic bacteria. *Appl Environ Microbiol* **58**: 2938-2947.
- Tamura K, Dudley J, Nei M, Kumar S (2007). MEGA4: Molecular evolutionary genetics analysis (MEGA) software version 4.0. *Mol Biol Evol* **24**: 1596-1599.
- Taylor GT, Iabichella M, Ho TY, Scranton MI, Thunell RC, Muller-Karger F *et al* (2001). Chemoautotrophy in the redox transition zone of the Cariaco Basin: A significant midwater source of organic carbon production. *Limnol Oceanogr* **46**: 148-163.
- Taylor J, Parkes RJ (1983). The cellular fatty-acids of the sulfate-reducing bacteria, *Desulfobacter* sp., *Desulfobulbus* sp. and *Desulfovibrio desulfuricans*. *J Gen Microbiol* **129**: 3303-3309.
- Thomsen U, Kristensen E (1997). Dynamics of ΣCO₂ in a surficial sandy marine sediment: the role of chemoautotrophy. *Aquat Microb Ecol* **12**: 165-176.
- Underwood GJC, Paterson DM, Parkes RJ (1995). The measurement of microbial carbohydrate exopolymers from intertidal sediments. *Limnol Oceanogr* **40**: 1243-1253.
- Underwood GJC, Smith DJ (1998). Predicting epipellic diatom exopolymer concentrations in intertidal sediments from sediment chlorophyll *a*. *Microb Ecol* **35**: 116-125.
- Underwood GJC, Kromkamp J (1999). Primary production by phytoplankton and microphytobenthos in estuaries. *Adv. Ecol. Res.* Academic Press Inc: San Diego. pp 93-153.
- Underwood GJC, Paterson DM (2003). The importance of extracellular carbohydrate production by marine epipellic diatoms. *Advances in Botanical Research, Vol 40*. Academic Press Ltd: London. pp 183-240.
- Underwood GJC, Boulcott M, Raines CA, Waldron K (2004). Environmental effects on exopolymer production by marine benthic diatoms: Dynamics, changes in composition, and pathways of production. *J Phycol* **40**: 293-304.
- van Duyl FC, de Winder B, Kop AJ, Wollenzien U (1999). Tidal coupling between carbohydrate concentrations and bacterial activities in diatom-inhabited intertidal mudflats. *Mar Ecol Prog Ser* **191**: 19-32.
- van Oevelen D, Middelburg JJ, Soetaert K, Moodley L (2006). The fate of bacterial carbon in an intertidal sediment: Modeling an in situ isotope tracer experiment. *Limnol Oceanogr* **51**: 1302-1314.
- Veuger B, van Oevelen D, Boschker HTS, Middelburg JJ (2006). Fate of peptidoglycan in an intertidal sediment: An in situ ¹³C-labeling study. *Limnol Oceanogr* **51**: 1572-1580.
- Webster G, Watt LC, Rinna J, Fry JC, Evershed RP, Parkes RJ *et al* (2006). A comparison of stable-isotope probing of DNA and phospholipid fatty acids to study prokaryotic functional diversity in sulfate-reducing marine sediment enrichment slurries. *Environ Microbiol* **8**: 1575-1589.
- Whiteley AS, Manefield M, Lueders T (2006). Unlocking the 'microbial black box' using RNA-based stable isotope probing technologies. *Curr Opin Biotechnol* **17**: 67-71.

Widdel F, Hansen TA (1992). The dissimilatory sulfate- and sulfur-reducing bacteria. In: Balows A, H. G. Trüper, W. Dworkin, W. Harder, Schleifer KH (eds). *The prokaryotes, 2nd ed.* Springer: Berlin, Germany. pp 583-624.

Wollast R (1998). Evaluation and comparison of the global carbon cycle in the coastal zone and in the open ocean. In: Brink KH, Robinson AR (eds). *The Sea*. John Wiley & Sons: New York, USA. pp 213-252.

Wright SW, Jeffrey SW (1987). Fucoxanthin pigment markers of marine-phytoplankton analyzed by HPLC and HPTLC. *Mar Ecol Prog Ser* **38**: 259-266.

Zhang CL, Huang ZY, Cantu J, Pancost RD, Brigmon RL, Lyons TW *et al* (2005). Lipid biomarkers and carbon isotope signatures of a microbial (*Beggiatoa*) mat associated with gas hydrates in the Gulf of Mexico. *Appl Environ Microbiol* **71**: 2106-2112.