

Carol Arnosti

Research Interests

- Organic carbon cycling by microbial communities in marine sediments and seawater
- Structural characterizations and transformations of macromolecular organic matter
- Development/application of novel methods to measure microbial enzyme activities
- Relationships between microbial community composition and function

Education

- Ph.D. M.I.T./Woods Hole Oceanographic Institution; Chemical Oceanography (1993)
B.A. Lawrence University, chemistry; *magna cum laude*, Phi Beta Kappa (1984)

Professional Experience

- Professor*, Dept. of Earth, Marine, and Environmental Sciences 7/2021-
Professor, Department of Marine Sciences 7/2006-6/2021
Visiting Professor, Max Planck Institute for Marine Microbiology 2019/20 (Dec-July);
(Bremen, Germany) 2018 (Jan-June);
2015/16 (Dec.-June);
2014 (Sept-Dec.)
2011 (Sept-Dec.)
2001/02 (June-May);
2000 (May-Aug);
1999 (Feb.-July)
Hanse Fellow, Hanse Institute for Advanced Studies 2015/16 (Dec.-June)
(Delmenhorst, Germany) 2014 (Sept-Dec.)
2001/02 (Sept.- May)
Associate Chair, Department of Marine Sciences 2005-2012
Guest Scientist, Alfred Wegener Institute for Polar and 2008 (Jan-May)
Marine Research (Bremerhaven, Germany)
Associate Professor, Department of Marine Sciences, 2001-6/2006
University of North Carolina-Chapel Hill
Assistant Professor, Department of Marine Sciences, 1995-2000
University of North Carolina-Chapel Hill
Fulbright and NSF/NATO Postdoctoral Fellow, 1993-1994
Dept. of Biogeochemistry,
Max Planck Institute for Marine Microbiology
(Bremen, Germany)
Graduate Student, Joint Program in Chemical Oceanography, 1987-1993
Massachusetts Institute of Technology and
Woods Hole Oceanographic Institution
Fulbright Fellow, Technical University of Aachen, and 1984-1986
Institute for Petroleum and Organic Geochemistry
(KFA-Jülich, Germany)

Field work: 29 research cruises in the North Atlantic, Pacific, and Arctic Oceans, in coastal North Carolina, and the Gulf of Mexico. One month at McMurdo Station, Antarctica.

Awards and Fellowships

Lifetime Achievement Award in Aquatic Enzymology (2016)
[International Conference on Enzymes in the Environment]
Hanse Fellowship, Hanse Institute for Advanced Studies, 2001-2002; 2014; 2015-16
Academic Leadership Fellowship, UNC; 2007
Lawrence University Alumni Distinguished Achievement Award, 1994
NSF/NATO Postdoctoral Fellowship, 1994
Fulbright Postdoctoral Fellowship (Germany), 1993-94
Ruth and Paul Fye Award [from WHOI], Best Student Paper, 1993
NSF Summer Institute in Japan, 1990
Graduate Fellowship, Office of Naval Research, 1987-1990
Thomas J. Watson Fellowship (Western Europe), 1986-1987
Fulbright Fellowship (Germany), 1984-1986
First Team Academic All-American (basketball): 1983; 1984
Phi Beta Kappa, 1983

Graduate sponsor/postdoctoral advisor/undergraduate mentor to 3 postdocs, 9 graduate students, committee member for 34 graduate students, 50 undergraduate research students

Select recent professional service activities

American Geophysical Union, secretary for Marine Geochemistry, within the Ocean Sciences section (2020 -)
NSF Advisory Committee for Geosciences; member (2020 -)
Ocean Studies Board, National Academy of Science; member (2019 -)
U.S. Committee for the UN Decade for Ocean Science for Sustainable Development, member (2020 -)
U.S. National Committee for SCOR (Scientific Committee on Oceanic Research), representative (2019 -)
American Association for the Advancement of Science, Section on Atmospheric and Hydrospheric Sciences; Member-at-large (2015-2019)
Ocean Carbon and Biogeochemistry (OCB) scientific steering committee, member (2013-2015)

Publications

[99] Balmonte JP, Meinhard Simon, Helge Ansgar-Giebel, and **Carol Arnosti**. (2021) A sea change in microbial enzymes: Heterogeneous latitudinal and depth-related gradients in bulk water and particle-associated enzymatic activities from 30°S to 59°N in the Pacific Ocean. *Limnol. Oceanogr.* doi: 10.1002/lno.11894

[98] Klassen, Leeann, Greta Reintjes, Jeffrey P. Tingley, Darryl R. Jones, Jan-Hendrik Hehemann, Adam D. Smith, Timothy D. Schwinghamer, **Carol Arnosti**, Long Jin, Trevor W. Alexander, Dallas Thomas, Rudolf Amann, Tim A. McAllister, and D. Wade Abbott. (2021) Quantifying fluorescent glycan uptake to elucidate strain-level variability in foraging behaviors of gut bacteria. *Microbiome*. 9:23 doi.org/10.1186/s40168-020-00975-x

[97] **Arnosti, C.**, Wietz, M. Brinkhoff, T., Hehemann, J.-H., Probandt, D., Zeugner, L., Amann, R. (2021) The biogeochemistry of marine polysaccharides: Sources, inventories, and bacterial drivers

of the carbohydrate cycle. *Annual Review of Marine Science*, vol. 13. doi: 10.1146/annurev-marine-023030-012810

[96] Reintjes, Greta, Bernhard M. Fuchs, Rudolf Amann, and **Carol Arnosti** (2020) Extensive microbial processing of polysaccharides in the South Pacific Gyre via selfish uptake and extracellular hydrolysis. *Frontiers Microbiol.* 11:583158. doi: 10.3389/fmicb.2020.583158

[95] Kharbush, Jenan, Benjamin A. S. Van Mooy, Hilary G. Close, **Carol Arnosti**, Rienk H Smittenberg, Frédéric A. C. Le Moigne, Gesine Mollenhauer, Barbara Scholz-Böttcher, Igor Obreht, Boris P. Koch, Kevin Becker, Morten H. Iversen, Wiebke Mohr. (2020) Particulate organic carbon deconstructed: Molecular and chemical composition of particulate organic carbon in the ocean. *Frontiers Marine Sci.* 7: 518. doi: 10.3389/fmars.2020.00518

[94] Reintjes G., Fuchs B.M., Scharfe M., Wiltshire K.H., Amann R., **Arnosti C.** (2020) Short-term changes in polysaccharide utilization mechanisms of marine bacterioplankton during a spring phytoplankton bloom. *Environ. Microbiol.* 22: 1884-1900. doi:10.1111/1462-2920.14971.

[93] Hoarfrost, Adrienne, Stephen Nayfach, Joshua Ladau, Shibu Yooseph, **C. Arnosti**, Christopher L Dupont, Katherine S. Pollard. (2020) Global ecotypes in the ubiquitous marine clade SAR86. *The ISME J.* 14: 178-188. doi: 10.1038/s41396-019-0516-7

[92] Ziervogel, K., and **C. Arnosti** (2020) Substantial carbohydrate hydrolase activities in the water column of the Guaymas Basin (Gulf of California). *Frontiers Mar Sci.* 6:815 doi: 10.3389/fmars.2019.00815

[91] **Arnosti, C.**, Hinrichs, K.-U., Coffinet, S., Wilkes, H., Pantoja, S. (2019) The enduring questions: What's for dinner? Where's my knife? ...and can I use my fingers? (Unanswered) questions related to organic matter and microbes in marine sediments. *Frontiers Marine Biogeochem.* 6: 629 doi: 10.3389/fmars.2019.00629

[90] Ziervogel, K., S.B. Joye, S. Kleindienst, S.Y. Malkin, U. Passow, A.D. Steen and **C. Arnosti.** (2019) Polysaccharide hydrolysis in the presence of oil and dispersants: insights into potential degradation pathway of expolymeric substances (EPS) from oil-degrading bacteria. *Elementa.* 7:31 doi.org/10.1525/elementa.371

[89] Balmonte, John Paul, Harald Hasler-Sheetal, Ronnie Glud, Thorbjørn J. Andersen, Mikael Sejr, Matthias Middelboe, Andreas Teske, **Carol Arnosti.** (2019) Sharp contrasts between freshwater and marine microbial enzymatic capabilities, community composition, and DOM pools in a NE Greenland fjord. *Limnol. Oceanogr.* doi: 10.1002/lno.11253

[88] Hoarfrost, A., Balmonte, JP, Ghobrial, S., Ziervogel, K., Bane, J., Gawarkiewicz G., **Arnosti, C.** Gulf Stream ring intrusion on the Mid-Atlantic Bight shelf affects microbially-driven carbon cycling. (2019) *Frontiers in Marine Science*, 6: 394 doi: 10.3389/fmars.2019.00394.

[87] Hoarfrost Adrienne, Nick Brown, C. Titus Brown, and **Carol Arnosti.** (2019) Sequencing data discovery with MetaSeek. *Bioinformatics*, 35: 4857-4859.

- [86] Hehemann, Jan-Hendrik, Greta Reintjes, Leeann Klassen, Adam D. Smith, Didier Ndeh, **Carol Arnosti**, Rudolf Amann, D. Wade Abbott. (2019) Single cell fluorescence imaging of glycan uptake by intestinal bacteria. *The ISME J* 13: 1883-1889. doi.org/10.1038/s41396-019-0406-z
- [85] Balmonte, John Paul, Andrew Buckley, Adrienne Hoarfrost, Sherif Ghobrial, Kai Ziervogel, Andreas Teske, **Carol Arnosti** (2019) Community structural differences shape microbial responses to high molecular weight organic matter. *Environ. Microb.*, 21:557-571 doi.org/10.1111/1462-2920.14485
- [84] Reintjes, G., **C. Arnosti**, B. M. Fuchs, and R. Amann. (2019) Selfish, sharing, and scavenging bacteria in the Atlantic Ocean: a biogeographic study of microbial substrate utilisation. *The ISME J*, 13: 1119-1132. doi.org/10.1038/s41396-018-0326-3.
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- [82] Balmonte, JP, A. Teske, and **C. Arnosti**. (2018) Structure and function of high Arctic pelagic, particle-associated, and benthic bacterial communities. *Environmental Microbiology* 20: 2941-2954.
- [81] Dittmar, T., and **C. Arnosti**. (2018) An inseparable liaison: marine microbes and nonliving organic matter. Chapt. 6, *Microbial Ecology of the Ocean* (D. Kirchman and J. Gasol, eds.); pp. 189-230.
- [80] Bullock, A., K. Ziervogel, S. Ghobrial, S. Smith, B. McKee, and **C. Arnosti**. (2017) A multi-season investigation of microbial community activities in two temperate coastal North Carolina rivers: evidence of spatial but not seasonal patterns. *Frontiers in Microbiol.*, 8: 2589. doi: 10.3389/fmicb.2017.02589.
- [79] Prairie, JC, Ziervogel, K., Camassa R, McLaughlin RM, White BL, Johnson Z., **Arnosti, C.** (2017) Ephemeral aggregate layers in the water column leave lasting footprints in the carbon cycle. *L&O Letters*. doi: 10.1002/lol2.10053
- [78] Hoarfrost, A., and **C. Arnosti**. (2017) Heterotrophic extracellular enzymatic activities in the Atlantic Ocean follow patterns across spatial and depth regimes. *Frontiers in Marine Sci.* 4:200. doi: 10.3389/fmars.2017.00200
- [77] Reintjes, G., **C. Arnosti**, B. M. Fuchs, and R. Amann (2017) An alternative polysaccharide uptake mechanism of marine bacteria. *The ISME J*. 11: 1640-1650. doi:10.1038/ismej.2017.26
- [76] Hoarfrost, A., R. Snider, and **C. Arnosti**. (2017) Improved measurement of extracellular enzymatic activities in subsurface sediments using a competitive desorption treatment. *Frontiers in Earth Sci*, 5:13 doi: 10.3389/feart.2017.00013

- [75] Balmonte, J.P., **C. Arnosti**, S. Underwood, B. McKee, and A. Teske (2016) Riverine bacterial communities reveal environmental disturbance signatures within the Betaproteobacteria and Verrucomicrobia. *Frontiers Microbiol.*: 7:1441 doi: 10.3389/fmicb.2016.01441
- [74] John, V., **C. Arnosti**, J. Field, E. Kujawinski, and A. McCormick (2016) The Role of Dispersants in Oil Spill Remediation – Fundamental Concepts, Rationale for Use, Fate and Transport Issues. *Oceanography* 29:108-117 doi: 10.5670/oceanog.2016.75
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- [72] **Arnosti, C.**, K. Ziervogel, T. Yang, and A. Teske (2016) Oil-derived marine aggregates – hot spots of polysaccharide degradation by specialized bacterial communities. *Deep Sea Res II* 129: 179-186.
- [71] Ziervogel, K., S.B. Joye, and **C. Arnosti.** (2016) Microbial enzymatic activity and secondary production in sediments affected by the sedimentation event of oily-particulate matter from the Deepwater Horizon oil spill. *Deep Sea Res II.* 129: 241-248.
- [70] Ziervogel, K., and **C. Arnosti** (2016) Enhanced protein and carbohydrate hydrolysis in plume-associated deep waters during the early stages of the Deepwater Horizon oil spill. *Deep Sea Res II* 129: 368-373.
- [69] Ziervogel K., Osburn C., Brym A., Battles J., Joye S.M., D'souza N., Montoya J., Passow U., and **Arnosti C.** (2016) Linking heterotrophic microbial activities with particle characteristics in the waters of the Mississippi River Delta in the aftermath of Hurricane Issac. *Frontiers in Marine Science* 3: 8. doi: 10.3389/fmars.2016.00008.
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- [67] Neumann, Anna Maria, John Paul Balmonte, Martine Berger, Helge-Ansgar Giebel, **Carol Arnosti**, Thorsten Brinkhoff, Meinhard Simon, and Matthias Wietz (2015) Different utilization of alginate and other algal polysaccharides by marine *Alteromonas macleodii* ecotypes. *Environ. Microbiol.* 17: 3857-3868. doi:10.1111/1462-2920.12862
- [66] Prairie JC, Ziervogel K, Camassa R, McLaughlin RM, White BL, Dewald C., **Arnosti C.** (2015) Delayed settling of marine snow: effects of density gradient and particle properties and implications for carbon cycling. *Marine Chem.* 175: 28-38.
- [65] **Arnosti, C.** (2015) Contrasting strategies in microbial degradation of organic matter in the water column and sediments: An example from Arctic fjords of Svalbard. *Marine Chem.* 168: 151-156. doi.org/10.1016/j.marchem.2014.09.019

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- [62] **Arnosti, C.** (2014) Patterns of microbially-driven carbon cycling in the ocean: Links between extracellular enzymes and microbial communities. Invited "outlook" article. *Advances in Oceanography* Article ID 706082, 12 pgs. doi.org/10.1155/2014/706082
- [61] Cardman, Z., **C. Arnosti**, A. Durbin, K. Ziervogel, C. Cox, A.D. Steen, and A. Teske (2014) Verrucomicrobia: candidates for polysaccharide-degrading bacterioplankton in an Arctic fjord of Svalbard *Appl. Environ. Microbiol.* 80: 3749-3756.
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- [59] **Arnosti, C.**, C. Bell, D.L. Moorhead, R.L. Sinsabaugh, A.D. Steen, M. Stromberger, M. Wallenstein, M. Weintraub. (2014) Extracellular enzymes in terrestrial, freshwater, and marine environments: perspectives on system variability and common research needs. *Biogeochemistry*, 117:5-21. DOI 10.1007/s10533-013-9906-5
- [58] **Arnosti, C.** and A.D. Steen. (2013) Patterns of extracellular enzyme activities and microbial metabolism in an Arctic fjord of Svalbard and in the northern Gulf of Mexico: Contrasts in carbon processing by pelagic microbial communities. *Frontiers in Microbiol.* 4: 318. doi: 10.3389/fmicb.2013.00318
- [57] Prairie, Jennifer C., Kai Ziervogel, **Carol Arnosti**, Roberto Camassa, Claudia Falcon, Shilpa Khatri, Richard M. McLaughlin, Brian L. White, Sungduk Yu. (2013) Delayed settling of marine snow at sharp density transitions driven by fluid entrainment and diffusion-limited retention. *Mar. Ecol Prog. Ser.* 487: 185-200.
- [56] Regnier, Pierre, Pierre Friedlingstein, Philippe Ciais, Fred T. Mackenzie, Nicolas Gruber, Ivan Janssens, Goulven G. Laruelle, Ronny Lauerwald, Sebastiaan Luyssaert, Andreas J. Andersson, Sandra Arndt, **Carol Arnosti**, Alberto V. Borges, Andrew W. Dale, Angela Gallego-Sala, Yves Godd eris, Jens Hartmann, Christoph Heinze, Tatiana Ilyina, Fortunat Joos, Douglas E. LaRowe, Jens Leifeld, Filip J. R. Meysman, Guy Munhoven, Peter A. Raymond, Renato Spahni, Parvatha Suntharalingam, Martin Thullner. (2013) The anthropogenic CO₂ budget considering the lateral transport from land to ocean. *Nature Geoscience* DOI: 10.1038/NGEO1830
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[54] **Arnosti, C.**, B. M. Fuchs, R. Amann, and U. Passow. (2012) Contrasting extracellular enzyme activities of particle associated bacteria from distinct provinces of the North Atlantic Ocean. *Frontiers in Microbiology*, 3:425. doi: 10.3389/fmicb.2012.00425

[53] Steen, A.D, K. Ziervogel, S. Ghobrial, and **C. Arnosti**. (2012) Functional variation among polysaccharide-hydrolyzing microbial communities in the Gulf of Mexico. *Marine Chem.* 138: 13-20.

[52] Martinez-Garcia, M., David M. Brazel, Brandon K. Swan, **Carol Arnosti**, Patrick S.G. Chain, Krista G. Reitinga, Gary Xie, Nicole J. Poulton, Monica Lluesma Gomez, Dashiell E. D. Masland, Brian Thompson, Wendy K. Bellows, Kai Ziervogel, Chien-Chi Lo, Sanaa Ahmed, Cheryl D. Gleasner, Chris J. Detter, and Ramunas Stepanauskas. (2012) Capturing single cell genomes of active polysaccharide degraders: an unexpected contribution of *Verrucomicrobia*. *PLoS ONE* 7(4): e35314. doi:10.1371/journal.pone.0035314

[51] Ziervogel, K., L. McKay, B. Rhodes, C.L. Osburn, J. Dickson-Brown, **C. Arnosti**, A. Teske. (2012) Microbial activities and dissolved organic matter dynamics in oil-contaminated seawater from the Deepwater Horizon oil spill site. *PLoS ONE* 7(4): e34816. doi:10.1371/journal.pone.0034816

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- [38] **Arnosti, C.**, K. Ziervogel, L. Ocampo, and S. Ghobrial. (2009) Enzyme activities in shallow permeable sediments and the water column from the northeastern Gulf of Mexico. *Est. Coastal Shelf Sci.* 84:202-208.
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- [35] **Arnosti, C.** (2008) Functional differences between Arctic sedimentary and seawater microbial communities: Contrasts in microbial hydrolysis of complex substrates. *FEMS Microb. Ecol.*, 66: 343-351.
- [34] Steen, A.D., L. Hamdan, and **C. Arnosti** (2008) Dynamics of high molecular weight dissolved organic carbon in the Chesapeake Bay: Insights from enzyme activities, carbohydrate concentrations, and microbial metabolism. *Limnol. Oceanogr.*, 53: 936-947.
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- [32] Ziervogel, K. and **C. Arnosti** (2008) Polysaccharide hydrolysis in aggregates and free enzyme activity in aggregate-free seawater from the northeastern Gulf of Mexico. *Environ. Microbiol.*, 10: 289-299.

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- [24] **Arnosti, C.**, S. Durkin, and W.H. Jeffrey (2005) Patterns of extracellular enzyme activities among pelagic microbial communities: Implications for cycling of dissolved organic carbon. *Aq. Microb. Ecol.* 38: 135-145.
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- [22] **Arnosti, C.** (2004) Speed bumps and barricades in the carbon cycle: Substrate structural effects on carbon cycling. *Marine Chem.* 92: 263-273.
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