

Zoe V. Finkel

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Current academic appointments

2018- Professor, Department of Oceanography, Dalhousie University
2018- Tier I Canada Research Chair in Marine Microbial Macroecology
2015-18 Professor, Environmental Science Program, Mount Allison University (MtA)
2011-18 Tier II Canada Research Chair in Marine Environmental Ecology
2016- Associate appointments to MtA Biology, Chemistry & Biochemistry departments
2015- Fellow of the Marine Biological Association of the United Kingdom
2014- External Graduate Faculty Member of the Ecology and Environmental Sciences Program, University of Maine
2009- Adjunct professor, College of Earth, Ocean and Environment, School of Marine Science and Policy, University of Delaware, Oceanography program

Education

2005 Ph.D. Oceanography, Rutgers University (Supervisors: P. Falkowski & O. Schofield)
1998 M.Sc. Biology, Dalhousie University (Supervisor: T. Platt)
1995 B. Sc. Environmental Science, University of Manitoba

Research Interests

My goal as a scientist is to improve our understanding of how marine microbes respond to environmental and climatic change. In particular, I am focused on improving our current understanding of how climate change will alter the ocean's capacity to absorb anthropogenic carbon dioxide through changes in phytoplankton production and community structure. My program is collaborative and interdisciplinary and includes experimental work on phytoplankton cultures (short-term physiological work, experimental evolution, transcriptomics), analyses of field datasets, analysis of phytoplankton fossil data, physiological and ecological modeling.

Publications (Trainees (HQP) in bold)

1. **Y. Liang, J. Koester, J. Liefer**, A.J. Irwin, ZV Finkel. 2019. Molecular mechanisms of temperature acclimation and adaptation in marine diatoms. *ISME J.* 10.1038/s41396-019-0441-9.

2. **J.D. Liefer, A. Garg, M.H. Fyfe, A.J. Irwin, I. Benner, C.M. Brown, M.J. Follows, A.W. Omta, Z.V. Finkel.** 2019. The macromolecular basis of phytoplankton C:N:P under nitrogen starvation. *Front. Microbiol.* 10: 763. 10.3389/fmicb.2019.00763
3. **L. Bretherton, M. Kamalanathan, J. Hillhouse, J. Genzer, H. Bacosa, Z.V. Finkel, A.S. Quigg.** 2019. Growth dynamics and domoic acid production of *Pseudo-nitzschia* sp. in response to oil and dispersant exposure. *Harmful Algae.* 86: 55-63. 10.1016/j.hal.2019.05.008
4. **L. Bretherton, M. Kamalanathan, J. Genzera, J. Hillhouse, S. Setta, Y. Liang, C.M. Brown, C. Xu, J. Sweet, U. Passow, Z.V. Finkel, A.J. Irwin, P.H. Santschi, A. Quigg.** 2019. Response of natural phytoplankton communities exposed to crude oil and chemical dispersants during a mesocosm experiment. *Aquatic Toxicology.* 206: 43-53. 10.1016/j.aquatox.2018.11.004
5. **P.A. Ajani, N. McGinty, Z.V. Finkel, A.J. Irwin.** 2018. Phytoplankton realised niches track changing oceanic conditions at a long-term coastal station off Sydney Australia. *Frontiers in Marine Science,* 5: 285. 10.3389/fmars.2018.00285
6. **N. McGinty, A.D. Barton, N.R. Record, Z.V. Finkel, A.J. Irwin.** 2018. Traits structure copepod niches in the North Atlantic and Southern Ocean. *Marine Ecology Progress Series.* 601:109-126.
7. **L. Bretherton, A. Williams, J. Genzer, J. Hillhouse, M. Kamalanathan, Z.V. Finkel, A.S. Quigg.** 2018. Physiological response of 10 phytoplankton species exposed to Macondo oil and the dispersant, Corexit. *J. Phycol.* 54: 317-328. 10.1111/jpy.12625
8. **J. Liefer, A. Garg, D. Campbell, A.J. Irwin, Z.V. Finkel.** 2018. Nitrogen starvation induces distinct photosynthetic responses and recovery dynamics in diatoms and prasinophytes. *PLOS One.* e0195705. 10.1371/journal.pone.0195705
9. **C.M. Mutshinda, Z.V. Finkel, C.E. Widdicombe, A.J. Irwin.** 2017. Phytoplankton traits from long-term oceanographic time-series. *Marine Ecology Progress Series.* 576:11-25.
10. **P. Tréguer, C. Bowler, B. Moriceau, S. Dutkiewicz, M. Gehlen, O. Aumont, L. Bittner, R. Dugdale, Z. Finkel, D. Iudicone, O. Jahn, L. Guidi, M. Lasbleiz, K. Leblanc, M. Levy, P. Pondaven.** 2017. Influence of diatom diversity on the ocean biological carbon pump. *Nature Geoscience.* 11: 27-37.
11. **A.W. Omta, D. Talmy, D. Sher, Z.V. Finkel, A.J. Irwin, M.J. Follows.** 2017. Extracting phytoplankton physiological traits from batch and chemostat culture data. *Limnology & Oceanography Methods.* 15: 453-466. doi/10.1002/lom3.10172

12. Schofield, O., G. Saba, K. Coleman, A.F. Carvalho, N. Couto, H. Ducklow, Z.V. Finkel, A. Irwin, A. Kahl, T. Miles, S. Stammerjohn, M. Montes-Hugo, N. Waite. 2017. Decadal variability in coastal phytoplankton community composition along a changing West Antarctic Peninsula. *Deep Sea Research Part I*. 124: 42-54.
13. **C. Fiset, J. Liefer**, A.J. Irwin, Z.V. Finkel. 2017. Methodological biases in estimates of macroalgal macromolecular composition. *Limnology & Oceanography Methods*. Available online. <http://onlinelibrary.wiley.com/doi/10.1002/lom3.10186/epdf>
14. **A.D. Barton**, A.J. Irwin, Z.V. Finkel, C. Stock. 2016. Anthropogenic climate change drives shift and shuffle in marine phytoplankton communities. *Proceedings of the National Academy of Sciences*. 113(11) 2964-2969.
15. A. Quigg, U. Passow, W-C. Chin, C. Xu, S. Doyle, **L. Bretherton**, M. Kamalanathan, A.K. Williams, J.B. Sylvan, Z.V. Finkel, A.H. Knapp, K.A. Schewehr, S. Zhang, L. Sun, T.L. Wade, W. Obeid, P.G. Hatcher, P.H. Santschi. 2016. The role of microbial exopolymers in determining the fate of oil and chemical dispersants in the ocean. *Limnology & Oceanography Letters*. Available online. 10.1002/lol2.10030
16. Z.V. Finkel, M.J. Follows, **J.D. Liefer, C.M. Brown, I. Benner**, A.J. Irwin. 2016. Phylogenetic diversity in the macromolecular composition of microalgae. *PLoS ONE*. 11(5) e0155977.
17. Z.V. Finkel, M.J. Follows, A.J. Irwin. 2016. Size-scaling of macromolecules and chemical energy content in the eukaryotic microalgae. *JPR*. 38(5): 1151-1162.
18. **Mutshinda, C.M.**, Z.V. Finkel, C. Widdicombe, A.J. Irwin. 2016. Ecological equivalence of species within phytoplankton functional groups. *Functional Ecology*. doi: 10.1111/1365-2435.12641.
19. A.J. Irwin, Z. V. Finkel, F. Müller-Karger, L. Troccoli. 2015. Phytoplankton adapt to changing ocean environments. *Proceedings of the National Academy of Sciences*. 112(18): 5762-5766.
20. A.J. Irwin, Z. V. Finkel, F. Müller-Karger, L. Troccoli. 2015. Reply to Brun et al.: Fingerprint of evolution revealed by shifts in realized phytoplankton niches in natural populations. *Proceedings of the National Academy of Sciences*. 112(38): E5225, doi: 10.1073/pnas.1514396112.
21. **E.A. Kerrigan**, A.J. Irwin, Z.V. Finkel. 2015. Community- and population-level changes in diatom size structure in a subarctic lake over the last two centuries. *PeerJ* 3: e1074. 10.7717/peerj.1074

22. S. Finnegan, S.C. Anderson, P.G. Harnik, C. Simpson, D.P. Tittensor, J.E. Byrnes, Z.V. Finkel, D.R. Lindberg, L. Hsiang Liow, R. R. Lockwood, H.K. Lotze, C.M. McClain, J.L. McGuire, A. O’Dea, J.M. Pandolfi. 2015. Paleontological baselines for evaluating extinction risk in the modern ocean. *Science*. 348: 567-570.
23. E.A. Orzechowski, R. R. Lockwood, J.E. Byrnes, S.C. Anderson, S. Finnegan, P.G. Harnik, Z.V. Finkel, D.R. Lindberg, L. Hsiang Liow, H.K. Lotze, C.M. McClain, J.L. McGuire, A. O’Dea, J.M. Pandolfi, C. Simpson, D.P. Tittensor. 2015. Marine extinction risk shaped by trait-environment interactions over 500 million years. *Global Change Biology*. 21(10): 3595-3607.
24. **Y. Wu**, D.A. Campbell, A.J. Irwin, D.J. Suggett, Z.V. Finkel. 2014. Ocean acidification enhances the growth rate of larger diatoms. *Limnology & Oceanography*. **59**: 1027-1034.
25. **Y. Wu, J. Jeans**, D.J. Suggett, Z.V. Finkel, D.A. Campbell. 2014. Large centric diatoms allocate more cellular nitrogen to photosynthesis to counter slower RUBISCO turnover rates. *Frontiers in Marine Science: Global Change and the Future Oceans*. doi: 10.3389/fmars.2014.00068
26. **A.D. Barton**, A.J. Pershing, E. Litchman, Z.V. Finkel, T. Kiørboe, N.R. Record, K.F. Edwards, B.A. Ward. 2013. The biogeography of plankton traits. *Ecology Letters*. **16**(4): 522-534.
27. **C.M. Mutshinda**, Z.V. Finkel, A.J. Irwin. 2013. Which environmental factors control phytoplankton populations? A Bayesian variable selection approach. *Ecological Modelling*. **269**: 1-8. Supplement. 10.1016/j.ecolmodel.2013.07.025
28. **A.D. Barton**, Z.V. Finkel, B.A. Ward, D.G. Johns, M.J. Follows. 2013. The roles of cell size and trophic strategy in North Atlantic diatom and dinoflagellate communities. *Limnology & Oceanography*. **58**: 254-266.
29. **C.M. Mutshinda**, L. Troccoli-Ghinaglia, Z.V. Finkel, F. Muller-Karger, A.J. Irwin. 2013. Environmental regulation of phytoplankton community structure in the Cariaco Basin. *Marine Biology Research*. **9**(3): 247-261.
30. **S.C. Sharpe, J.A. Koester, M. Loebl**, A.M. Cockshutt, D.A. Campbell, A.J. Irwin, Z.V. Finkel. 2012. Metabolic size scaling within and across cryptic species of *Ditylum brightwellii* (Bacillariophyceae). *PLoS One* **7**(12): e52916. 10.1371/journal.pone.0052916.
31. P.G. Harnik, H. K. Lotze, S.C. Anderson, Z.V. Finkel, S. Finnegan, D.R. Lindberg, L.H. Liow, R. Lockwood, C.M. McClain, J.L. McGuire, A. O’Dea, J.M. Pandolfi, C. Simpson, and D.P. Tittensor. 2012. Extinctions in ancient and modern seas. *Trends in Ecology and Evolution*. **27**: 608-617.

32. **H. van Tol**, A.J. Irwin, Z.V. Finkel. 2012. Macroevolutionary trends in silicoflagellate skeletal morphology: the costs and benefits of silicification. *Paleobiology*. **38**(3): 391-402.
33. **M. Grey**, Z.V. Finkel, P.K. Pufahl, L.M. Reid. 2012. Evolutionary mode of the ostracod, *Velatomorpha altilus*, at the Joggins Fossil Cliffs UNESCO World Heritage Site. *Lethaia*. 45(4): 615-623.
34. A.J. Irwin, **A.M. Nelles**, Z.V. Finkel. 2012. Phytoplankton niches estimated from field data. *Limnology & Oceanography*. **57**(3): 787-797.
35. **M. Grey** and Z.V. Finkel. 2011. The Joggins Fossil Cliffs UNESCO world heritage site: a review of recent research. *Atlantic Geology*. **47**: 185-200.
36. **Z-P. Mei**, Z.V. Finkel, A.J. Irwin. 2011. Phytoplankton growth allometry and size-dependent C:N stoichiometry revealed by a variable quota model. *Marine Ecology Progress Series*, **434**: 29-43, 10.3354/meps09149
37. **B-Z. Chen**, A.J. Irwin, Z.V. Finkel. 2011. Biogeographic distribution of diversity and size-structure of organic-walled dinoflagellate cysts. *Marine Ecology Progress Series*. **425**:35-45. 10.3354/meps08985
38. Quigg, A.S., A.J. Irwin, Z.V. Finkel. 2011. Testing the evolutionary inheritance of elemental stoichiometry in phytoplankton. *Proceedings of the Royal Society B*. **278**:526-534. 10.1098/rspb.2010.1356
39. Z.V. Finkel and **B. Kotrc**. 2010. Silica use through time: macroevolutionary change in the morphology of the diatom frustule. *Geomicrobiology Journal*. **16**:1-13. 10.1080/01490451003702941
40. **Loebl, M.**, Cockshutt, A.M., Campbell, D.A., Z.V. Finkel. 2010. Physiological basis for high resistance to photoinhibition under nitrogen depletion in *Emiliana huxleyi*. *Limnology & Oceanography*. **55**: 2150-60. 10.4319/lo.2010.55.5.2150
41. Z.V. Finkel, **K.A. Matheson**, **K. Regan**, A.J. Irwin. 2010. Genotypic and phenotypic variation in diatom silicification under paleoceanographic conditions. *Geobiology*. **8**(5): 433-445, 10.1111/j.1472-4669.2010.00250.x
42. K.J. Flynn, J.A. Raven, T.A.V. Rees, Z.V. Finkel, A.S Quigg, J. Beardall. 2010. Is the growth rate hypothesis applicable to microalgae? *Journal of Phycology*. **46**(1): 1-12. 10.1111/j.1529-8817.2009.00756.x

43. Z.V. Finkel, J. Beardall, K.J. Flynn, A.S. Quigg, T.A.V. Rees, J.A. Raven. 2010. Phytoplankton in a changing world: cell size and elemental stoichiometry. *Journal of Plankton Research*. **32**(1):119-137. 10.1093/plankt/fbp098
44. **T. Key, A. McCarthy**, D.A. Campbell, **C. Six**, S. Roy, Z.V. Finkel. 2010. Cell size tradeoffs govern light exploitation strategies in marine phytoplankton. *Environmental Microbiology*. **12**(1):95-104. 10.1111/j.1462-2920.2009.02046.x
45. Z. V. Finkel, A.J. Irwin, **C. Jacob-Vaillancourt**, E. Reavie, J.P. Smol. 2009. Environmental control of aquatic microbial community size structure varies across aquatic ecosystems. *Proceedings of the Royal Society B*. **276**: 1627-1634. (Cover image)
46. **Z-P. Mei**, Z.V. Finkel, A.J. Irwin. 2009. Growth rate allometry in response to light and nutrient limitation in phytoplankton. *Journal of Theoretical Biology*. **259**: 582-588.
47. J. Beardall, D. Allen, J. Bragg, Z.V. Finkel, K.J. Flynn, A.S. Quigg, T.A.V. Rees, A. Richardson and J.A. Raven. 2009. Allometry and stoichiometry of unicellular, colonial and multicellular phytoplankton. Tansley Review. *New Phytologist* **181**(2), 295–309. 10.1111/j.1469-8137.2008.02660.x
48. A.J. Irwin and Z.V. Finkel. 2008. Mining a sea of data: deducing environmental controls of remote-sensed chlorophyll. *PLoS ONE*. **3**(1): E3836
10.1371/JOURNAL.PONE.0003836
49. **C Six**, Z.V. Finkel, F. Rodriguez, D. Marie, F. Partensky, D.A. Campbell. 2008. Contrasting photoacclimation costs in ecotypes of the eukaryotic picoplankter *Ostreococcus*. *Limnology & Oceanography*. **53**(1): 255-265
50. **C. Six**, Z.V. Finkel, A.J. Irwin, D.A. Campbell. 2007. Light variability illuminates niche-partitioning among oceanic picocyanobacteria. *PLoS ONE* **2**(12): e1341.
doi:10.1371/journal.pone.0001341
51. Z. V. Finkel, **J. Sebbo**, M. Katz, A.J. Irwin, O. Schofield, S. Feist-Burkhardt, J. Young, P. Falkowski. 2007. A universal driver of macroevolutionary change in the size of phytoplankton over the Cenozoic. *Proceedings of the National Academy of Sciences USA*. **104**(51): 20416-20420.
52. Berman-Frank, A.S. Quigg, Z. V. Finkel, A.J. Irwin, L. Haramaty. 2007. Nitrogen-fixation strategies and Fe requirements in cyanobacteria. *Limnology & Oceanography*. **52**(5): 2260-2269.
53. Z. V. Finkel, A. Quigg, **R. Chiampi**, O. Schofield & P. Falkowski. 2007. Phylogenetic diversity in Cd:P regulation in marine phytoplankton. *Limnology & Oceanography*. **52**(3): 1131-1138.

54. Z.V. Finkel, A. Quigg, J. A. Raven, J. R. Reinfelder, O. E. Schofield, and P. G. Falkowski. 2006. Irradiance and the elemental stoichiometry of marine phytoplankton. *Limnology & Oceanography*. **51**: 2690-2701.
55. A.J. Irwin, Z. V. Finkel, O. Schofield & P. Falkowski. 2006. Scaling-up from nutrient physiology to the size-structure of phytoplankton communities. *Journal of Plankton Research*. **28**(5): 459-471.
56. J.A. Raven, Z. V. Finkel, A.J.Irwin. 2005. Picophytoplankton: bottom-up and top-down controls on ecology and evolution. *Vie et Mileu*. **55** (3/4): 209-215.
57. Z. V. Finkel, M. Katz, J. Wright, O. Schofield & P. Falkowski. 2005. Climatically driven macroevolutionary patterns in the size of marine diatoms over the Cenozoic. *Proceedings of the National Academy of Sciences USA*. **102**(25): 8927-8932.
58. P. Frost, M. Evans-White, Z. V. Finkel, T. Jensen, V. Matzek. 2005. Are you what you eat? Physiological constraints on organismal stoichiometry in an elementally imbalanced world. *Oikos*. **109**:18-28.
59. M.E. Katz, Z.V. Finkel, D. Gryzebek, A.H. Knoll, P.G. Falkowski. 2004. Eucaryotic phytoplankton: evolutionary trajectories and global biogeochemical cycles. *Annual Review of Ecology, Evolution and Systematics*. **35**:523-556.
60. Z. V. Finkel, A. J. Irwin and O. Schofield. 2004. Resource limitation alters the $\frac{3}{4}$ size scaling of metabolic rates in phytoplankton. *Marine Ecology Progress Series*, Special theme section: *Emergent properties of complex marine systems: a macroecological perspective*. **273**:269-279.
61. O. Schofield, R. Arnone, P. Bissett, C. Davis, Z. Finkel, M. Oliver, M. Moline. 2004. Watercolors in the coastal zone: what can we see? *Oceanography*. **17**(2):30-37.
62. A.S. Quigg, Z. V. Finkel, A. J. Irwin, Y. Rosenthal, T-Y Ho, J. R. Reinfelder, O. Schofield, F. M. M. Morel and P. G. Falkowski. 2003. The evolutionary inheritance of elemental stoichiometry in marine phytoplankton. *Nature*, **425**: 291-294.
63. T-Y Ho, A.S. Quigg, Z. V. Finkel, A. J. Milligan, K. Wyman, P. G. Falkowski, and F. M. M. Morel. 2003. The elemental composition of some marine phytoplankton. *Journal of Phycology*, **39**(6):1145-1159.
64. Z. V. Finkel and A.J. Irwin. 2001. Light absorption and the filter amplification correction: species-specific and size-specific effects. *Journal of Experimental Marine Biology and Ecology*, **259**:51-61.

65. Z. V. Finkel. 2001. Light absorption and the size scaling of light-limited growth and photosynthesis in marine diatoms. *Limnology & Oceanography*, **46**(1): 86-94.

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Edited journal issues, Chapters, & Non-Refereed Publications

- Z.V. Finkel & A.J. Irwin. Accepted. Phytoplankton. In: Encyclopaedia of Astrobiology. Springer. <https://www.springer.com/gp/book/9783642112744>
- A.J. Irwin and Z. V. Finkel. 2018. Phytoplankton functional types: A trait perspective. In: *The Microbial Ecology of the Ocean*. 3rd edition. Editors: J. Gasol and D. Kirchman. Wiley. Chapter 11: Pages 435-465.
- Z.V. Finkel. 2016. Silicification in the microalgae. In: *Microalgal physiology. Developments in Applied Phycology Series*. Editors: John Raven, John Beardall, Michael Borowitzka. Invited chapter. Pages 289-300. doi 10.1007/978-3-319-24945-2.
- Z.V. Finkel. 2014. Marine net primary production. 7 pages. In: *Handbook of Global Environmental Pollution Vol. 1. Global Environmental Change*. Editor: Bill Freedman. Springer. 966 pages. doi 10.1007/978-94-007-5784-4_42.
- B. Beisner and Z.V. Finkel. Editors. 2014. Plankton functional traits. *Journal of Plankton Research Virtual Issue*: http://www.oxfordjournals.org/our_journals/plankt/resource/functional_traits.html
- Z. V. Finkel. 2007. Does size matter? The evolution of modern marine food webs. In: *The evolution of aquatic photoautotrophs*. Eds.: P.G. Falkowski & A.H. Knoll. Academic Press.
- Z. V. Finkel, A.J. Irwin, P. Falkowski & O. Schofield. 2002. Cell size and optimal pigment concentrations under sub-saturating growth irradiance. *Ocean optics*, **XVI**: 7p.
- A.J. Irwin and Z.V. Finkel. 1999. Review of Selection in Natural Populations, *Quarterly Review of Biology*, **74**(1):73-74.