

## MICHAEL S. TWARDOWSKI

Harbor Branch Oceanographic Institute, Florida Atlantic University  
5600 US 1 N, Ft. Pierce, FL 34946

office: (772) 242-2220; FAU Extension: x62220; cell: (401)862-9067

email: [mtwardowski@fau.edu](mailto:mtwardowski@fau.edu)

website: <http://www.fau.edu/hboi/personal/>

### PROFESSIONAL PREPARATION

Postdoc	Environmental Optics Fellowship, <i>Oregon State University</i>	1998-1999
Ph.D.	Biological Oceanography, <i>University of Rhode Island</i>	1998
B.S.	Biology with Honors, <i>Trinity University, San Antonio, Texas</i>	1992

### APPOINTMENTS

Professor, <i>Harbor Branch Oceanographic Institute, Florida Atlantic University</i>	2015-present
Director of Research, <i>WET Labs, Inc.</i>	2005-2015
Adjunct Professor, <i>University of Connecticut</i>	2005-present
Adjunct Professor, <i>Graduate School of Oceanography, University of Rhode Island</i>	2003-present
East Coast Research Director, <i>WET Labs, Inc.</i>	2002-2005
Visiting Scientist, <i>Graduate School of Oceanography, University of Rhode Island</i>	2000-2003
Oceanographer, <i>WET Labs, Inc.</i>	2000-2015
ASEE Fellow, <i>Stennis SC and Washington D.C., Naval Research Labs</i>	2000
Research Associate, <i>COAS, Oregon State University</i>	1999-2000

*Ph.D. Advisor:* Percy Donaghay (University of Rhode Island)

*Postdoctoral Advisors:* Drs. Ronald Zaneveld and Timothy Cowles (Oregon State Univ.)

- Leads a research team in oceanographic research, specializing in ocean optics
- Develops optical sensors for oceanographic research applications

### PROFESSIONAL AWARDS

WET Labs Postdoctoral Fellowship, 1998.

Early Career Faculty Award, Office of International Research and Development, Oregon State University, 2000.

ASEE Visiting Faculty Fellowship, Naval Research Labs, Stennis Space Center (R. Arnone, A. Weidemann) and Washington, D.C., (Curt Davis), 2000.

*Spinoff* technology selection, NASA Innovative Partnership Program, <http://www.sti.nasa.gov/tto/Spinoff2005/PDF/accessible.pdf>, 2005.

NATO Visiting Research Fellowship, Naval Underwater Research Centre, La Spezia, Italy, 2010.

## MICHAEL S. TWARDOWSKI

### PUBLICATIONS: PEER-REVIEWED (reverse chronological)

- 55 Brady, P., A. Gilerson, G. Kattawar, J. Sullivan, M. **Twardowski**, H. Dierssen, M. Gao, K. Travis, R.I. Etheredge, C. Carrizo, Y. Gu, B. Russell, S. Zhao, and M. Cummings. 2015. Better than a mirror: nature's solution for open ocean camouflage. *Science*, in review.
- 54 Dombroski, J., and M. **Twardowski**. 2015. Identification of fluorophoric components of dissolved organic matter in Narragansett Bay, Rhode Island using excitation-emission matrices and Parallel Factor Analysis (PARAFAC). *Science of the Total Environment*, in review.
- 53 Mouw, C., S. Greb, D. Aurin, P. DiGiacomo, Z-P. Lee, M. **Twardowski**, C. Binding, C. Hu, R. Ma, T. Moore, W. Moses, and S. Craig. 2015. Aquatic color radiometry remote sensing of coastal and inland waters: challenges and recommendations for future satellite missions. *Remote Sensing of Environment*, <http://dx.doi.org/10.1016/j.rse.2015.02.001>.
- 52 Slivkoff, M., W. Klonowski, M. **Twardowski**, and S. Freeman. 2015. Determining the near forward volume scattering function from the LISST-100X particle size analyzer. *Journal of Atmospheric and Oceanic Technology*, in review.
- 51 **Twardowski**, M.S., D.W. Townsend, J.M. Sullivan, C. Koch, N.R. Pettigrew, J. O'Donnell, C. Stymiest, J. Salisbury, T. Moore, R. Young-Morse, N.D. Stockley, and J.R. Morrison. 2015. Developing the first operational nutrient observatory for ecosystem, climate, and hazard monitoring for NERACOOS. *Marine Technology Society Journal*, in press.
- 50 Zamankhan, H, J. Westrick, F.R. Anscombe, R. Stumpf, T.T. Wynne, J. Sullivan, M.S. **Twardowski**, T. Moore, H. Choi. 2015. Chapter 3: sustainable monitoring of algal blooms, *In: Harmful Algal Blooms*, in press.
- 49 Churnside, J., J. Sullivan, and M. **Twardowski**. 2014. Lidar extinction-to-backscatter ratio of the ocean. *Optics Express*, 22(15):18698-18706.
- 48 Moore, T. M. **Twardowski**, and C. Koch. 2014. Developing predictive models for cyanobacterial blooms in western Lake Erie. *Lakeline*, 34(1):26-28.
- 47 Wei, J., M.R. Lewis, R. Van Dommelen, C.J. Zappa, and M.S **Twardowski**. 2014. Wave-induced light field fluctuations in measured irradiance depth profiles: a wavelet analysis. *Journal of Geophysical Research – Oceans*, 119, doi:10.1002/2013JC009572.
- 46 Chang, G., C. Jones, M. **Twardowski**. 2013. Prediction of optical variability in dynamic nearshore environments. *Methods in Oceanography*, <http://dx.doi.org/10.1016/j.mio.2013.12.002>.
- 45 Gilerson, A., J. Stepinski, A. Ibrahim, A. Tonizzo, Y. You, J. Sullivan, M. **Twardowski**, H. Dierssen, B. Russell, M. Cummings, P. Brady, S. Ahmed, and G. W. Kattawar. 2013. Benthic effects on the polarization of light in shallow waters. *Applied Optics*, 52(36):8685-8705.
- 44 Randolph, K., H. Dierssen, M. **Twardowski**, A. Cifuentes-Lorenzen, and C. Zappa. 2013. Optical measurements of small deeply-penetrating bubble populations generated by breaking waves in the Southern Ocean. *Journal of Geophysical Research – Oceans*, 119, doi:10.1002/2013JC009227.

## MICHAEL S. TWARDOWSKI

- 43 Sullivan, J., M. **Twardowski**, J.R.V. Zaneveld, and C. Moore. 2013. Measuring optical backscattering in water, *In: A. Kokhanovsky (Ed), Light Scattering Reviews 7: Radiative Transfer and Optical Properties of Atmosphere and Underlying Surface*, Springer Praxis Books, doi: 10.1007/978-3-642-21907-8\_6, pp. 189-224.
- 42 Talapatra, S., Jiarong Hong, Malcolm McFarland, Aditya R. Nayak, Cao Zhang, Joseph Katz, James Sullivan, M. **Twardowski**, Jan Rines, Percy Donaghay. 2013. Characterization of biophysical interactions in the water column using *in situ* digital holography. *Marine Ecological Progress Series*, 473:29-51, doi:10.3354/meps10049.
- 41 Dickey, T. and Others. 2012. Recent advances in the study of optical variability in the near-surface and upper ocean. *Journal of Geophysical Research*, doi:10.1029/2012JC007964.
- 40 Gleason, A., K. Voss, H.R. Gordon, M. **Twardowski**, J. Sullivan, C. Trees, A. Weidemann, J-F Berthon, D. Clark, and Z-P Lee. 2012. Detailed validation of ocean color bidirectional effects in various Case I and Case II waters. *Optics Express*, 20(7), 7630-7645.
- 39 Groundwater, H., M. **Twardowski**, H. Dierssen, A. Sciandre, and S. Freeman. 2012. Determining oceanic particle size distributions and particle composition: a new SEM-EDS protocol with validation and comparison to other methods. *Journal of Atmospheric and Oceanic Technology*, 29, 433:449, DOI: 10.1175/JTECH-D-11-00026.1.
- 38 **Twardowski**, M., X. Zhang, S. Vagle, J. Sullivan, S. Freeman, H. Czerski, Y. You, L. Bi, and G. Kattawar. 2012. The optical volume scattering function in a surf zone inverted to derive sediment and bubble particle subpopulations, *Journal of Geophysical Research*, 117, C00H17, doi:10.1029/2011JC007347.
- 37 Bhandari, P. K. Voss, L. Logan, and M. **Twardowski**. 2011. The variation of the polarized downwelling radiance distribution with depth in the coastal and clear ocean. *Journal of Geophysical Research*, 116, C00H10, doi:10.1029/2011JC007320.
- 36 Chang, G. and M. **Twardowski**. 2011. Effects of physical forcing and particle characteristics on underwater imaging performance, *Journal of Geophysical Research*, 116, C00H03, doi:10.1029/2011JC007098.
- 35 Czerski, H., M. **Twardowski**, X. Zhang, and S. Vagle. 2011. Resolving size distributions of bubbles with radii less than 30 microns with optical and acoustical methods, *Journal of Geophysical Research*, 116, C00H11, doi:10.1029/2011JC007177.
- 34 Lee, Z., V. Lance, S. Shang, R. Vaillancourt, S. Freeman, B. Lubac, B. Hargreaves, C. Del Castillo, R. Miller, M. **Twardowski**, G. Wei. 2011. An assessment of optical properties and primary production derived from remote sensing in the Southern Ocean (SO GasEx). *Journal of Geophysical Research*, 116, C00F03, doi:10.1029/2010JC006747.
- 33 You, Y., A. Tonizzo, A.A. Gilerson, M.E. Cummings, P. Brady, J.M. Sullivan, M.S. **Twardowski**, H.M. Dierssen, S.A. Ahmed, and G.W. Kattawar. 2011. Measurements and simulations of polarization states of underwater light in clear oceanic waters, *Optics Express*, 50(24):4873-4893.

## MICHAEL S. TWARDOWSKI

- 32 Zhang, X., M.S. **Twardowski**, and M. Lewis. 2011. Retrieving composition and sizes of oceanic particle subpopulations from the volume scattering function. *Applied Optics*, 50:1240-1259.
- 31 Aurin, D., H.M. Dierssen, M.S. **Twardowski**, and C.S. Roesler. 2010. Optical complexity in Long Island Sound and implications for coastal ocean color remote sensing. *Journal of Geophysical Research*, 115, C07011, doi:10.1029/2009JC005837.
- 30 Chang, G., M.S. **Twardowski**, Y. You, M. Moline, P. Zhai, S. Freeman, M. Slivkoff, F. Nencioli, and G. Kattawar. 2010. Effects of optical variability on the prediction of underwater visibility. *Applied Optics*, 49(15):2784-2796.
- 29 Nencioli, F., G. Chang, M. **Twardowski**, and T.D. Dickey. 2010. Optical characterization of an eddy-induced diatom bloom west of the island of Hawaii. *Biogeosciences*, 7:151-162.
- 28 Voss, K.J., S. McLean, M. Lewis, C. Johnson, S. Flora, M. Feinholz, M. Yarbrough, C. Trees, M. **Twardowski**, D. Clark. 2010. An example crossover experiment for testing new vicarious calibration techniques for satellite ocean color radiometry. *Journal of Atmospheric and Oceanic Technology*, 27:1747:1759, DOI: 10.1175/2010JTECHO737.1.
- 27 Gordon, H.R., M.R. Lewis, S.D. McLean, M.S. **Twardowski**, S.A. Freeman, K.J. Voss, and G.C. Boynton. 2009. Spectra of particulate backscattering in natural waters. *Optics Express*, 17(18), 16192-16208.
- 26 Sullivan, J.M., and M.S. **Twardowski**. 2009. Angular shape of the volume scattering function in the backward direction. *Applied Optics*, 48:6811-6819.
- 25 Tonizzo, A., J. Zhou, A. Gilerson, M. **Twardowski**, D. Gray, R. Arnone, B. Gross, F. Moshary, and S. Ahmed. 2009. Polarization measurements in coastal waters: hyperspectral and multiangular analysis. *Optics Express*, 17, 5666-5683.
- 24 Zhang, X., L. Hu, M.S. **Twardowski**, and J.M. Sullivan. 2009. Scattering by solutions of major sea salts. *Optics Express*, 17:19580-19585.
- 23 Glenn, S., C. Jones, M. **Twardowski**, L. Bowers, J. Kerfoot, J. Kohut, D. Webb, and O. Schofield. 2008. Glider observations of sediment resuspension in a Middle Atlantic Bight fall transition storm. *Limnology and Oceanography*, 53(5, part II), 2180-2196.
- 22 Huot, Y., A. Morel, M. **Twardowski**, D. Stramski, and R. Reynolds. 2008. Particle optical backscattering along a chlorophyll gradient in the upper layer of the eastern South Pacific. *Biogeosciences*, 5:495-507, [www.biogeosciences.net/5/495/2008/](http://www.biogeosciences.net/5/495/2008/).
- 21 Stramski, D., R. Reynolds, M. Babin, H. Claustre, S. Kaczmarek, M. Lewis, R. Rottgers, A. Sciandra, M. Stramska, and M. **Twardowski**. 2008. Relationships between POC and optical properties of surface waters in the South Pacific and Atlantic Oceans. *Biogeosciences*, 5: 171-183, [www.biogeosciences.net/5/171/2008/](http://www.biogeosciences.net/5/171/2008/).
- 20 Huot, Y., M. Babin, F. Bruyant, C. Grob, M. S. **Twardowski**, and H. Claustre. 2007. Does chlorophyll a provide the best index of phytoplankton

## MICHAEL S. TWARDOWSKI

- biomass for primary productivity studies? *Biogeosciences*, 4:853-868, [www.biogeosciences.net/4/853/2007/](http://www.biogeosciences.net/4/853/2007/).
- 19 **Twardowski**, M.S., H. Claustre, S.A. Freeman, D. Stramski, and Y. Huot. 2007. Optical backscattering properties of the “clearest” natural waters. *Biogeosciences*, 4, 1041–1058, [www.biogeosciences.net/4/1041/2007/](http://www.biogeosciences.net/4/1041/2007/).
  - 18 Sullivan, J.M., M.S. **Twardowski**, J.R.V. Zaneveld, C. Moore, A. Barnard, P. Donaghay, and B. Rhoades. 2006. The hyperspectral temperature and salinity dependencies of absorption by water and heavy water in the 400-750 nm spectral range. *Applied Optics*, 45:5294-5309.
  - 17 Sullivan, J.M., M.S. **Twardowski**, Donaghay, P.L., and Freeman, S.A. 2005. Using scattering characteristics to discriminate particle types in US coastal waters, *Applied Optics*, 44:1667-1680.
  - 16 **Twardowski**, M.S., M. Lewis, A. Barnard, J.R.V. Zaneveld. 2005. In-water instrumentation and platforms for ocean color remote sensing applications. *In: Remote Sensing of Coastal Aquatic Waters*, R. Miller, C. Del Castillo, and B. McKee [Eds.], Springer Publishing, Dordrecht, Netherlands, pp. 69-100.
  - 15 Zaneveld, J.R.V., M.S. **Twardowski**, M. Lewis, and A. Barnard. 2005. Radiative transfer and remote sensing. *In: Remote Sensing of Coastal Aquatic Waters*, R. Miller and C. Del-Castillo [Eds.], Springer-Kluwer Publishing, pp. 1-20.
  - 14 Boss, E., W. S. Pegau, M. Lee, M. S. **Twardowski**, E. Shybanov, G. Korotaev, and F. Baratange. 2004. The particulate backscattering ratio at LEO 15 and its use to study particles composition and distribution. *Journal of Geophysical Research*, 109, C01014, doi:10.1029/2002JC001514.
  - 13 **Twardowski**, M.S., E. Boss, J.M. Sullivan, and P.L. Donaghay. 2004. Modeling spectral absorption by chromophoric dissolved organic matter (CDOM). *Marine Chemistry*, 89: 69-88, doi:10.1016/j.marchem.2004.02.008.
  - 12 Eisner, L., M.S. **Twardowski**, T.J. Cowles, and M.J. Perry. 2003. Resolving phytoplankton photoprotective:photosynthetic carotenoid ratios on fine scales using in situ spectral absorption measurements. *Limnology and Oceanography*, 48:632-646.
  - 11 McManus, M.M., AL Alldredge, A Barnard, E Boss, J Case, TJ Cowles, PL Donaghay, LB Eisner, DJ Gifford, CF Greenlaw, C Herren, DV Holliday, D Johnson, S MacIntyre, D McGehee, TR Osborn, MJ Perry, R Pieper, JEB Rines, DC Smith, JM Sullivan, MK Talbot, MS **Twardowski**, A Weidemann and JR Zaneveld. 2003. Characteristics, distribution and persistence of thin layers over a 48 hour period. *Marine Ecology Progress Series*, 261:1-19.
  - 10 Miller, R., M.S. **Twardowski**, C. Moore, and C. Casagrande. 2003. The Dolphin: Technology to support remote sensing bio-optical algorithm development and applications. *Backscatter*, 14(2):8-12.
  - 9 Rines, J.E.B., P.L. Donaghay, M. Deksheniaks, J.M. Sullivan, and M.S. **Twardowski**. 2002. Thin layers and camouflage: hidden *Pseudonitzschia* spp. (Bacillariophyceae) populations in a fjord in the San Juan

## MICHAEL S. TWARDOWSKI

- Islands, Washington, U.S.A. *Marine Ecology Progress Series*, 225:123-137.
- 8 **Twardowski, M.S.**, and P.L. Donaghay. 2002. Photobleaching of aquatic dissolved materials: absorption removal, spectral alteration, and their interrelationship. *Journal of Geophysical Research*, 107(C8):6.1-6.12.
  - 7 Boss, E., M.S. **Twardowski**, and S. Herring. 2001. Shape of the particulate beam attenuation spectrum and its inversion to obtain the shape of the particulate size distribution. *Applied Optics*, 40:4885-4893.
  - 6 Boss, E., W.S. Pegau, W.D. Gardner, J.R.V. Zaneveld, A.H. Barnard, M.S. **Twardowski**, G.C. Chang, and T.D. Dickey. 2001. Spectral particulate attenuation in the bottom boundary layer of a continental shelf. *Journal of Geophysical Research*, 106(C5):9509-9516.
  - 5 Deksheniaks, M.M., P.L. Donaghay, J.M. Sullivan, J.E.B. Rines, T.R. Osborn, and M.S. **Twardowski**. 2001. Temporal and spatial occurrence of thin phytoplankton layers in relation to physical processes. *Marine Ecology Progress Series*, 223:61-71.
  - 4 **Twardowski, M.S.** and A. Barnard. 2001. Observing the ocean: sensing technology and observation platforms. *Maritimes*, 43(4).
  - 3 **Twardowski, M.S.**, and P.L. Donaghay. 2001. Separating in situ and terrigenous sources of absorption by dissolved material in coastal waters. *Journal of Geophysical Research*, 106(C2):2545-2560.
  - 2 **Twardowski, M.S.**, E. Boss, J.B. Macdonald, W.S. Pegau, A.H. Barnard, and J.R.V. Zaneveld. 2001. A model for estimating bulk refractive index from the optical backscattering ratio and the implications for understanding particle composition in Case I and Case II waters. *Journal of Geophysical Research*, 106(C7):14,129-14,142.
  - 1 **Twardowski, M.S.**, J.M. Sullivan, P.L. Donaghay, and J.R.V. Zaneveld. 1999. Microscale quantification of the absorption by dissolved and particulate material in coastal waters with an ac-9. *Journal of Atmospheric and Oceanic Technology*, 16(12):691-707.

### PUBLICATIONS: PEER-REVIEWED, WEB ONLY

- Twardowski M.**, Jonasz M. 2006. VSF at the small angles for natural dispersions and power-law slopes ([www.tpdsci.com/Tpc/VsfSmlAngNatDspSlp.php](http://www.tpdsci.com/Tpc/VsfSmlAngNatDspSlp.php)). In: *Top. Part. Disp. Sci.* ([www.tpdsci.com](http://www.tpdsci.com)).
- Twardowski M.**, Jonasz M. 2006. Power law in spectral scattering by natural dispersions: Derivation ([www.tpdsci.com/Tpc/AtnCfSptPwLwNatDsp.php](http://www.tpdsci.com/Tpc/AtnCfSptPwLwNatDsp.php)). In: *Top. Part. Disp. Sci.* ([www.tpdsci.com](http://www.tpdsci.com)).
- Twardowski M.**, Jonasz M. 2006. Power law in spectral scattering by natural dispersions: Finite range of the particle diameter ([www.tpdsci.com/Tpc/AtnCfSptPwLwNatDsp.php](http://www.tpdsci.com/Tpc/AtnCfSptPwLwNatDsp.php)). In: *Top. Part. Disp. Sci.* ([www.tpdsci.com](http://www.tpdsci.com)).
- Twardowski M.**, Jonasz M. 2006. Power law in spectral scattering and attenuation by natural dispersions (<http://www.tpdsci.com/Tpc/ScaCfSptPwLwNatDsp.php>). In: *Top. Part. Disp. Sci.* ([www.tpdsci.com](http://www.tpdsci.com)).

**MICHAEL S. TWARDOWSKI**

**PUBLICATIONS: NOT PEER-REVIEWED**

**Twardowski, M.S.** 2000. Ocean research in the ocean state. *The Rhode Island Trooper*, 12(1):107-109.

**PUBLICATIONS: DISSERTATION**

**Twardowski, M.S.** 1998. The finescale distribution, origin, and photobleaching of the spectral absorption of dissolved organic matter in coastal waters. University of Rhode Island, Kingston.