

## **MICHAEL S. TWARDOWSKI**

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### **PROFESSIONAL PREPARATION**

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

### **APPOINTMENTS**

Research Professor, <i>Harbor Branch Oceanographic Institute, FAU</i>	2015-present
Associate Director, <i>NOAA Cooperative Institute, CIOERT, HBOI</i>	2018-present
Program Lead, Maritime Sensing, <i>I-SENSE, FAU</i>	2016-present
Affiliate Professor, <i>Ocean Engineering, FAU</i>	2017-present
Affiliate Professor, <i>Dept. Biological Sciences and Graduate College, FAU</i>	2018-present
President, <i>Sunstone Scientific LLC</i>	2017-present
Senior Engineer, <i>SEACORP Inc.</i>	2015-present
Director of Research and Vice President, <i>WET Labs, Inc.</i>	2005-2015
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 ocean research
- NASA PACE Mission Science Team
- Holds a Secret clearance; HBOI is a Homeland Security designated research facility
- Over \$16M in external grant and contract awards

### **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.

Adjunct Professor, University of Rhode Island, 2003.

Adjunct Professor, University of Connecticut, 2005.

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

NASA, Distinguished Science Award, GASEX, 2008.

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

NASA PACE Science Team, 2015-2019.

Visiting Scientist Fellowship, LOG, Wimereux, France, 2017.

Visiting Scientist, CNR-ISAC, Frascati, Italy, 2018.

Love Your Lagoon Honoree, HBOI Foundation, 2018.

### PATENTS

Twardowski, M., and J. Sullivan. 2014. Digital holographic microscopy apparatus and method for clinical diagnostic hematology. PATENT US 20140220622 A1.

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

- 100 Chowdary, J., P. Zhai, F. Xu, H. Dierssen, A. Ibrahim, R. Frouin, L. Remer, E. Boss, M. **Twardowski**, and X. Zhang. 2019. Radiative transfer in oceanic-atmospheric coupled systems. *Frontiers in Marine Science*, conditionally accepted.
- 99 Boss, E., M. **Twardowski**, D. McKee, I. Cetinic, and W. Slade. 2019. Beam transmission and attenuation coefficients: instruments, characterization, field measurements, and data analysis protocols. In: A. Neely (Ed.), *NASA Ocean Optics Protocols, Vol I, Inherent Optical Property Measurements and Protocols*, pp. 22-36, conditionally accepted.
- 98 Moore, T.S, J.H. Churnside, J. Sullivan, M. **Twardowski**, A. Nayak, M. McFarland, N. Stockley, R. Gould, T. Johengen, and S. Ruberg. 2019. Vertical distributions of blooming cyanobacteria populations in a freshwater lake from lidar observations. *Remote Sensing of Environment*, 225:347-367.
- 97 Randolph, K., H.M. Dierssen, M. **Twardowski**, X. Zhang, W.B. Balch, and V. Lance. 2018. Biological and physical sources of optical backscattering in the Southern Ocean. *J. Geophys. Res.*, in review.
- 96 **Twardowski**, M., and A. Tonizzo. 2019. Correction: Twardowski, M.; Tonizzo, A. Ocean Color Analytical Model Explicitly Dependent on the Volume Scattering Function. *Applied Sciences* 2018, 8, 2684. *Applied Sciences*, 9(5): 938; <https://doi.org/10.3390/app9050938>.
- 95 Agaliate, J., R. Rottgers, M. **Twardowski**, and D. McKee. 2018. Evaluation of a flow cytometry method to determine size and real refractive index distributions in natural marine particle populations. *Applied Optics*, 57(7):1705-1716.
- 94 Figueroa, E., M. Cone, C. Orrico, M. Dewey, A. Derr, M. **Twardowski**, and E. Fry. 2018. Integrating Cavity Device Measuring the Optical Backscattering Coefficient in Fluid. *Applied Optics*, 57(24):6943-6951.
- 93 Gleason, A., Voss, K., H. Gordon, and M. **Twardowski**. 2018. Measuring and modeling the polarized upwelling radiance distribution in clear and coastal waters. *Applied Sciences, special issue on Ocean Optics*, 8, 2683; doi:10.3390/app8122683.

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- 92 Lefering, I. R. Rottgers, C. Utschig, M. **Twardowski**, and D. McKee. 2018. Measurement uncertainties in PSICAM and reflective tube absorption meters. *Optics Express*, 26(19):24384-24402.
- 91 Nayak, A., M. McFarland, M. **Twardowski**, and J. Sullivan. 2018. On plankton distributions and biophysical interactions in diverse coastal and limnological environments. *Proc. SPIE, Ocean Sensing and Monitoring X*, DL 10631.
- 90 Ottaviani, M., R. Foster, A. Gilerson, A. Ibrahim, C. Carrizo, A. El-habashi, B Cairns, J. Chowdhary, C. Hostetler, J. Hair, S. Burton, Y. Hu, M. **Twardowski**, N. Stockley, D. Gray, W. Slade, and I. Cetinic. 2018. Airborne and shipborne polarimetric measurements over open ocean and coastal waters: intercomparisons and implications for spaceborne observations. *Remote Sensing of the Environment*, 206, 375-390, doi:10.1016/j.rse.2017.12.015.
- 89 Ouyang, B., M. **Twardowski**, Y. Li, and F. Dalgleish. 2018. Investigation of a Compressive Line Sensing Hyperspectral Imaging Sensor. *Proc. SPIE, Unconventional Imaging*, 106773Q; doi: 10.1117/12.2309937.
- 88 Ramirez-Perez, M., M. **Twardowski**, C.C. Trees, J. Piera, and D. McKee. 2018. Inversion of *in situ* absorption and attenuation measurements to estimate constituent concentrations in optically complex shelf seas. *Journal of Geophysical Research - Oceans*, DOI 10.1002/2017JC013453.
- 87 Strait, C., M. Twardowski, F. Dalgleish, A. Tonizzo, and A. Vuorenkoski. 2018. Development and assessment of lidar modeling to retrieve IOPs. *Proc. SPIE, Ocean Sensing and Monitoring X*, DL 10631.
- 86 Tonizzo, A., B. Russell, J. Sullivan, and M. **Twardowski**. 2018. Propagation of bioluminescent signals to near-surface from mesopelagic waters. *Proc. SPIE, Ocean Sensing and Monitoring X*, DL 10631-41.
- 85 **Twardowski**, M., S. Freeman, S. Pegau, J.R.V. Zaneveld, J. Mueller, and E. Boss. 2018. Chapter 2: Reflective tube absorption meters. In: A. Neely (Ed.), *NASA Ocean Optics Protocols, Vol I, Inherent Optical Property Measurements and Protocols*, pp. 37-51.
- 84 **Twardowski**, M., C. Jamet, and H. Loisel. 2018. Analytical Model to Derive Suspended Particulate Matter Concentration in Natural Waters by Inversion of Optical Attenuation and Backscattering. *Proc. SPIE, Ocean Sensing and Monitoring X*, DL 10631.
- 83 **Twardowski**, M., R. Rottgers, and D. Stramski. 2018. Chapter 1: The absorption coefficient, an overview. In: A. Neely (Ed.), *NASA Ocean Optics Protocols, Vol I, Inherent Optical Property Measurements and Protocols*, pp. 5-21.
- 82 **Twardowski**, M., and A. Tonizzo. 2018. Progress on a new analytical algorithm to retrieve inherent optical properties from ocean color remote sensing. *Proc. IGARSS*, 3540.
- 81 **Twardowski**, M., and A. Tonizzo. 2018. Ocean color analytical model explicitly dependent on the volume scattering function. *Applied Sciences, special issue on Ocean Optics* (feature publication), 8, 2684; doi:10.3390/app8122684.

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- 80 Werdell, J., L.I.W. McKinna, E. Boss, S.G. Ackleson, S.E. Craig, W.W. Gregg, Z-P. Lee, S. Maritorena, C.S. Roesler, C.S. Rousseaux, D. Stramski, J.M. Sullivan, M.S. **Twardowski**, M. Tzortziou, X. Zhang. 2018. An overview of approaches and challenges for retrieving marine inherent optical properties from ocean color remote sensing. *Progress in Oceanography*, doi.org/10.1016/j.pocean.2018.01.001.
- 79 Zamankhan Malayeri, H., M. **Twardowski**, J. Sullivan, T. Moore, and H. Choi. 2018. Correlation of cyanobacterial harmful bloom monitoring parameters: A case study on western Lake Erie. *AIMS Environmental Science*, 2018, 5(1): 24-34. doi: 10.3934/environsci.2018.1.24.
- 78 Moore, T., C.B. Mouw, M. **Twardowski**, J. Sullivan, A. Burtner, A. Ciochetto, M. McFarland, A. Nayak, D. Palladino, N. Stockley, T. Johengen, A. Yu, S. Ruberg, A. Weidemann. 2017. Bio-optical properties in western Lake Erie during intense summertime algal blooms: impacts for remote sensing applications. *Frontiers in Marine Science*, 4(300):1:20, doi: 10.3389/fmars.2017.00300.
- 77 Nayak, A., M. McFarland, N. Stockley, M. **Twardowski**, and J. Sullivan. 2017. In situ particle characterization and evidence of ubiquitous particle orientation in the ocean using a submersible holographic imaging system. *Proc. SPIE, Ocean Sensing and Monitoring IX*, 101860C.
- 76 Nayak, A., M. McFarland, J. Sullivan, and M. **Twardowski**. 2017. Evidence for ubiquitous preferential particle orientation in representative oceanic shear flows. *Limnology and Oceanography*, doi: 10.1002/lno.10618.
- 75 Schulien, J., M.J. Behrenfeld, J. Hair, C. Hostetler, and M. **Twardowski**. 2017. Vertically- resolved phytoplankton carbon and net primary production from a High Spectral Resolution Lidar. *Optics Express*, 25(12):13577-13587.
- 74 Stockley, N.D., R. Rottgers, D. McKee, I. Lefering, J.M. Sullivan, and M.S. **Twardowski**. 2017. Assessing uncertainties in scattering correction algorithms for reflective tube absorption measurements made with a WET Labs ac-9. *Optics Express*, 25(24):A1139-A1153.
- 73 Tonizzo, A., M. **Twardowski**, S. McLean, K. Voss, M. Lewis, and C. Trees. 2017. Closure and uncertainty assessment for ocean color reflectance using measured volume scattering functions and reflective tube absorption coefficients with novel correction for scattering. *Applied Optics*, 56(1):130-146.
- 72 **Twardowski**, M., and A. Tonizzo. 2017. Scattering and absorption effects on asymptotic light fields in seawater. *Optics Express*, 25(15):18122-18130.
- 71 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. 2016. Response to comment on “Open-ocean fish reveal an omnidirectional solution to camouflage in polarized environments.” *Science*, 353(6299):552, DOI: 10.1126/science.aaf5018.

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- 70 Gu, Y., C. Carrizo, A. A. Gilerson, P. Brady, M. Cummings, M. **Twardowski**, J. Sullivan, A. Ibrahim, and G. Kattawar. 2016. Polarimetric imaging and retrieval of target polarization characteristics in underwater environment. *Applied Optics*, 55(3):626-637.
- 69 Hair, J., C. Hostetler, Y. Hu, M. Behrenfeld, C.F. Butler, D.B. Harper, R. Hare, R. Berkoff, A. Cook, J. Collins, N. Stockley, M. **Twardowski**, I. Cetinic, R. Ferrare, and T. Mack. 2016. Combined Atmospheric and Ocean Profiling from an Airborne High Spectral Resolution Lidar. *European Physical Journal Conferences*, 119:22001, DOI: 10.1051/epjconf/201611922001.
- 68 Nardelli, S., and M.S. **Twardowski**. 2016. Improving assessments of chlorophyll concentration from *in situ* optical measurements. *Optics Express*, 24(22):A1374-A1389.
- 67 Sun, B., G.W. Kattawar, P. Yang, M.S. **Twardowski**, J.M. Sullivan. 2016. Simulation of the optical properties of ocean diatom chains. *Journal of Quantitative Spectroscopy and Radiative Transfer*, 178:390-399.
- 66 **Twardowski**, M.S., J. Sullivan, and F. Dalgleish. 2016. Novel technologies to study undisturbed particle fields in the ocean. *Sea Technology*, 57(2):15-19.
- 65 Valente, A., Sathyendranath, S., Brotas, V., Groom, S., Grant, M., Taberner, M., Antoine, D., Arnone, R., Balch, W. M., Barker, K., Barlow, R., Bélanger, S., Berthon, J.-F., Besiktepe, S., Brando, V., Canuti, E., Chavez, F., Claustre, H., Crout, R., Frouin, R., García-Soto, C., Gibb, S. W., Gould, R., Hooker, S., Kahru, M., Klein, H., Kratzer, S., Loisel, H., McKee, D., Mitchell, B. G., Moisan, T., Muller-Karger, F., O'Dowd, L., Ondrusek, M., Poulton, A. J., Repecaud, M., Smyth, T., Sosik, H. M., **Twardowski**, M., Voss, K., Werdell, J., Wernand, M., and Zibordi, G. 2016. A compilation of global bio-optical *in situ* data for ocean-colour satellite applications. *Earth Syst. Sci. Data Discuss.*, doi:10.5194/essd-2015-37.
- 64 Zamankhan, H, J. Westrick, F.R. Anscombe, R. Stumpf, T.T. Wynne, J. Sullivan, M.S. **Twardowski**, T. Moore, H. Choi. 2016. Chapter 3: Sustainable monitoring of algal blooms, *In: Sustainable Water Management and Technologies*, D.H. Chen [Ed.], Taylor and Francis Group, Boca Raton, FL, pp. 65-90.
- 63 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. Open-ocean fish reveal an omnidirectional solution to camouflage in polarized environments. *Science*, 350(6263):965-969.
- 62 Jay, D.A., S.A. Talke, A. Hudson, and M. **Twardowski**. 2015. Estuary Turbidity Maxima Revisited: Instrumental Approaches, Remote Sensing, Modeling Studies, and New Directions. *In: Fluvial-Tidal Sedimentology, Developments in Sedimentology*, vol. 68, P. Ashworth, J. Best, and D. Parsons [Eds], Elsevier, pp. 49-109.
- 61 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.

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- 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>.
- 60 **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*, 49(3):72-80.
- 59 Vuorenkoski, A.K., Dalglish, F.R., **Twardowski**, M.S., Ouyang, B., and Trees. C. C. 2015. Semi-empirical inversion technique for retrieval of quantitative attenuation profiles with underwater scanning LIDAR systems. *Proc. SPIE 9459, Ocean Sensing and Monitoring VII*, 94590E-94590E6.
- 58 Churnside, J., J. Sullivan, and M. **Twardowski**. 2014. Lidar extinction-to-backscatter ratio of the ocean. *Optics Express*, 22(15):18698-18706.
- 57 Moore, T. M. **Twardowski**, and C. Koch. 2014. Developing predictive models for cyanobacterial blooms in western Lake Erie. *Lakeline*, 34(1):26-28.
- 56 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.
- 55 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>.
- 54 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.
- 53 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.
- 52 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.
- 51 Talapatra, S., J. Hong, M. McFarland, A. R. Nayak, C. Zhang, J. Katz, J. Sullivan, M. **Twardowski**, J. Rines, P. 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.

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- 50 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.
- 49 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.
- 48 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.
- 47 Sullivan, J., M. **Twardowski**, P. Donaghay, J. Rines, M. McFarland, S. Talapatra, J. Katz, J. Churnside, and A. Weidemann. 2012. Biological thin layers: history, ecological significance and consequences to oceanographic sensing systems. *Proc. SPIE 8372, Ocean Sensing and Monitoring IV*, 83720U (June 12, 2012); doi:10.1117/12.921156.
- 46 Talapatra, S., J. Sullivan, J. Katz, M. **Twardowski**, H. Czerski, P. Donaghay, J. Hong, J. Rines, M. McFarland, A. Nayak, C. Zhang. 2012. Application of in-Situ Digital Holography in the Study of Particles, Organisms and Bubbles within Their Natural Environment. *Proc. SPIE 8372, Ocean Sensing and Monitoring IV*.
- 45 **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.
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- 43 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.
- 42 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.
- 41 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.
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- 39 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.
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- 36 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.
- 35 Groundwater, H.S.; Michael S. **Twardowski**; Heidi M. Dierssen; Antoine Sciandre; Scott A. Freeman. 2010. A method for determining oceanic particle size distributions and particle composition using scanning electron microscopy coupled with energy dispersive spectroscopy. *Proc. SPIE. 7729, Scanning Microscopy 2010*, 77290E. (June 02, 2010) doi: 10.1117/12.853455.
- 34 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.
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