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SURFCLAMS, OFFSHORE WIND FARMS, AND NUMERICAL MODELS

By John M. Klinck

At some point, you may have enjoyed clam chowder that likely was made from Atlantic surfclams harvested on the U.S. east coast continental shelf. The lucrative Atlantic surfclam fishery, with annual revenues of about $30 million, is unique to the U.S. east coast continental shelf. Cool bottom water temperatures, the Cold Pool, set the habitat for this bivalve species along the inner and middle parts of the shelf and allow this cold water species to survive.

Atlantic surfclams burrow in the bottom sediments. As a result, the commercial fishing industry harvests Atlantic surfclams with hydraulic dredges that are pulled along the bottom. The dredge disturbs the upper few tens of centimeters of the bottom to dislodge the animals from the sediments and then collects them with the dredge. The harvested clams are then landed at a port on the U.S. east coast and transferred to a processing plant. This all seems rather straightforward.

Typical surf clam fishing boat. *Photo by Daphne Munroe.*

Areas of the Middle Atlantic Bight of the US east coast continental shelf are being studied for installation of offshore wind turbines as a way to expand carbon-free energy generation. Wind turbines not only create structures on the shelf, but also need rock scour pads to protect the structures and cables to distribute electrical power and provide communication for the turbines.

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OLD DOMINION UNIVERSITY

Inside

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SURFCLAMS | Cont.

How does offshore wind energy development connect with Atlantic surfclams? Many of the sites designated for the installation of offshore wind farms overlap with areas of high Atlantic surfclam biomass and hence areas where the commercial fishery operates. The use of dredges and limited maneuverability of the surfclam fishing boats will prevent operation in and around the offshore wind farms. What are the potential impacts of this restriction on the fishery?

To answer this question, **John Klinck and Eileen Hofmann** (CCPO) are participating in a BOEM (Bureau of Ocean Energy Management)-funded project, led by Daphne Munroe (Rutgers University), and includes co-investigators, Eric Powell (University of Southern Mississippi), Sarah Borsetti (Rutgers University), and Andrew Scheld (VIMS), that uses an integrated modeling framework to assess the effects of offshore wind energy development on the Atlantic surfclam fishery. The model includes components that simulate the Atlantic surfclam biomass, fishing boat capabilities, behavior/decision making of boat captains, and the economics (boats and processing plant operation) of the fishery (see model description in Munroe et al., 2022, ICES *J. Mar. Sci.*)

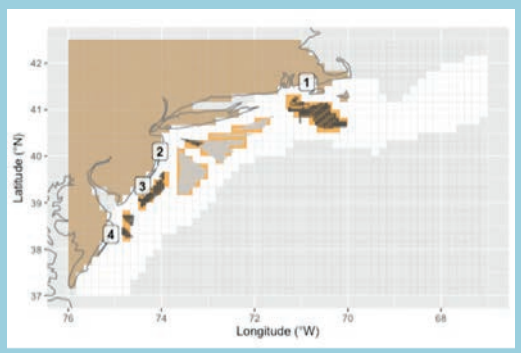


Figure 1. A map of the Middle Atlantic Bight showing fishing ports (numbered squares), surfclam habitat (white squares), and wind far lease areas (light and dark grey patches). Orange indicated grids excluded from fishing. Figure taken from BOEM report 2022-065.

The model works much like a computer game where boats leave port, travel to some location based on the captain's memory to fish for a time, and return to port where they sell their catch. The Atlantic surfclam fishable biomass is set with rules that specify the biology of the species (growth, mortality, recruitment). The economics of the fishery are assessed at the end of the simulation based on the landings, boat activity, and operational costs for the boats and processing plants.

What have we learned about offshore wind energy development and the Atlantic surfclam fishery? Based on the simulations, fishing boats that are not allowed to travel through the currently leased and proposed future offshore wind farm areas will make fewer fishing trips because of the extended time required to go around the lease areas, producing an overall revenue decrease. This is especially true for fishing boats with a home port in the mid-Atlantic region (see economic details in Scheld et al., 2022, ICES *J. Mar. Sci.*). These analyses of anticipated financial impacts on the Atlantic surfclam fishery can provide a basis for mitigation that are developed along with decisions about offshore wind energy generation capacity and placement.

What is next? We are extending our integrated modeling approach to assess the effects of warming bottom temperatures, resulting from climate change, on the distribution of Atlantic surfclams on the continental shelf. These simulations use projected future hydrographic conditions on the Mid-Atlantic continental shelf obtained from simulations provided by Enrique Curchitser (Rutgers University). Restructuring the biomass distribution will affect how this resource is harvested with implications for the operation and economics of the Atlantic surfclam fishery. These simulations address tradeoffs for the fishery resulting from the short-term effects of offshore wind energy development and the long-term effects of clam habitat change.

The lucrative Atlantic sea scallop fishery in the Mid-Atlantic is facing similar challenges from offshore wind energy development. We have revised our modeling framework to represent the scallop's biology and the structure of the scallop fishery. Simulations are ongoing to assess the potential effects of offshore wind energy development and climate change on this fishery.

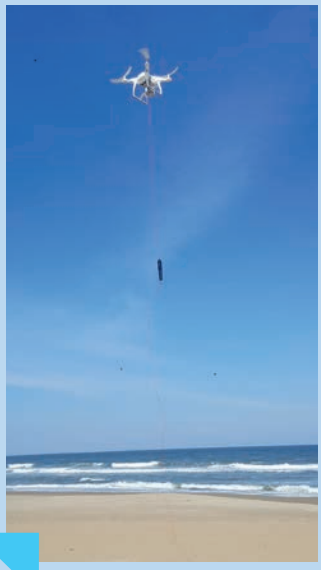
Our integrated, agent-based model framework links biological, environmental, social, and economic components of a marine fishery. This linked structure allows an analysis of the effects of changes in fishery management, environmental conditions, or uses of the continental shelf. We hope that understanding these causes and effects will allow competing groups using the continental shelf to make better, more coordinated decisions.

HF RADAR CALIBRATIONS TAKE FLIGHT

By Teresa Updyke, CCPO Project Scientist

A benefit of my job is that I'm always learning something new—for example, how to fly a drone! I work with coastal high frequency (HF) radar systems that measure ocean surface currents and, in 2019, I became a licensed small, unmanned aircraft systems pilot so I could use drones to calibrate these radars.

Coastal HF radars bounce radio signals off ocean waves and analyze the return signal to determine water speed. An antenna calibration is needed to accurately determine from which direction a reflected signal came so that speeds can be properly mapped. During a calibration, a radio signal is tracked across all viewing angles of the antenna; this is called an antenna pattern measurement (APM).



Drone with radio signal source

The calibration benefits from measuring a signal coming from offshore and so a traditional APM method involves the use of a boat. A new APM method, developed by researchers at the University of California Santa Barbara (UCSB), uses a radio signal source that hangs below a quadcopter drone on a small wire. The drone flies a pre-programmed arc over the water, while the radar on the beach tracks the signal.

When I first considered using this method at ODU stations, I had no experience with drones and piloting over water is not the best way to learn! George McLeod, director of ODU's Center for Geospatial Science, Education, and Analytics, was able to provide guidance, equipment, and piloting expertise for the first calibration missions. Later, I purchased a Mavic 2 Pro drone and after some practice, I was able to perform the calibrations. Now I've logged 21 successful missions, calibrated the antennas more frequently, and saved significant funds that would have gone to boat hires.

Programmed flight path for Little Island Park radar station calibration

A selfie taken in Newfoundland, Canada

Teresa doing a training/practice flight

In the Community

A NIGHT AT THE MUSEUM

The Virginia Museum of Contemporary Art in Virginia Beach hosted Maya Lin's "A Study of Water" from April to September 2022 that showcased the artist's sculptural interpretations of water. One of the sculptures featured was *Marble Chesapeake & Delaware Bay* (2022) that showed the waterways and connectivity of Chesapeake. Luisa Igloria, Professor of English at ODU and Poet Laureate of the Commonwealth of Virginia at the time, organized an evening of *"community participation through a reading/sharing of responses to Maya Lin's work*." In addition to poets, Professor Igloria included contributions from individuals from oceanography, as well as other disciplines who "*feel drawn to the many ways in which water serves both as living resource and metaphor for multiple concerns, conditions, and experiences in our lives*."

Eileen Hofmann. Photo credit: *The Princess Anne Independent News*

Eileen Hofmann (CCPO) and Professor Margie Mulholland and Professor Fred Dobbs from the Department of Ocean & Earth Sciences were invited to contribute to this evening on July 7, 2022 to reflect on how their personal experiences and experiences as ocean scientists related to Maya Lin's artistic interpretation of water and Chesapeake Bay. Eileen presented a short essay, "*Change to Change the Chesapeake,*" that reflected on the Chesapeake Bay ecosystem and how it is changing. The essay topic was motivated by the importance of connectivity in water systems highlighted in Maya Lin's sculpture of the Chesapeake. The essay was influenced by Eileen's research that considers responses of the Chesapeake Bay ecosystem to declining abundances of eastern oysters, hypoxia, eutrophication, and climate change. The linkages and connections across the watershed, environment and ecosystem make the overall Chesapeake system vulnerable to changes from these stressors. The implication is that we need to change to change the Chesapeake.

Atkinson Scholarship Update

Noah Hendricks is a recent graduate of the Ocean and Earth Sciences department at ODU. He distinguished himself by earning all A's in his classes and by working with **Sönke Dangendorf** on an analysis of the processes associated with rising sea level along the east coast of North America. The research resulted in a publication in *Nature Communications* in 2023. Based on his stellar academic performance, Noah was chosen to be the first recipient of the Larry P. Atkinson Endowed Scholarship. A formal announcement of the choice was made at the OCEANS 2022 meeting held October 17–20 in Virginia Beach. Noah is now at Tulane University, pursuing a doctoral degree.

Noah with his parents, Angela and Stephen Hendricks.

Letter from the Director

While the focus of CCPO is coastal physical oceanography, we are proud of having a wider vision of interesting activities. Some of this wider vision has to do with research involving processes on the shelf that go beyond water characteristics and water motion. Analysis of bivalve biology on the shelf and in the estuaries is one example. Extending this analysis to consider the economics and human decisions in a shelf fishery is another. Finally, contributing to the national effort to measure water motion in the U.S. coastal waters is a third. We hope to continue expanding our interests in understanding ocean processes.

We also enjoy contributing to the cultural life of the local community. The participation by Eileen in the art show hosted by the local Virginia Museum of Contemporary Art is an example. In the past we have shared our interest in the ocean with various middle schools and have helped local Boy Scout troop members earn the oceanography merit badge. Covid restrictions put a stop to many of these activities, but recent times have allowed us to participate in school STEM fairs and provide programs for local Cub Scouts. We look forward to expanding these programs.

While our main focus is on scientific research on various ocean processes, we feel a strong obligation to share our enthusiasm for understanding the environment with local groups of any age. These programs with young people remind us how exciting the world is and how important it is to encourage everyone to share that excitement.

— Dr. John Klinck, Director of CCPO & Professor of Oceanography

JUST THE FACTS

Presentations

Dinniman, M., P. St-Laurent, K. Arrigo, **E. Hofmann**, and G. van Dijken, Sensitivity of the relationship between Antarctic ice shelves and iron supply to projected changes in the atmospheric forcing, 2022 Ocean Sciences Meeting (virtual), February 28–March 4, 2022.

Dinniman, M., Sensitivity of Antarctic Ice Shelf Basal Melt to Projected Changes in the Atmosphere (and Why It Matters), CCPO and ICAR Spring 2022 Virtual Seminar Series, April 4, 2022.

Ezer, T., From Global Sea Level Rise Over the Last Century to Norfolk Flood Projection for the Next Century, CCPO and ICAR Spring 2022 Virtual Seminar Series, February 14, 2022.

Ezer, T., The science of sea level rise and flooding, Living With Rising Water: Symposium on Sea Level Rise Science, Impacts and Solutions, Chrysler Museum of Art, Norfolk, VA, April 9, 2022.

Ezer, T., Global to regional sea level variability and changing ocean dynamics since 1900, Department of Environment and Geography, University of York, UK, July 22, 2022.

Ezer, T., Interconnections between sea level, hurricanes, and the Gulf Stream: analysis of century-long global sea level and regional models, Invited Keynote Speaker: 12th International Workshop on Modeling the Ocean (IWMO-2022), Ann Arbor, MI, June 28, 2022.

Ezer, T. and S. Dangendorf, Analysis of century-long sea level reconstruction reveals changes in spatiotemporal variability and ocean dynamics that can impact coastal sea level, 2022 Ocean Sciences Meeting (virtual), February 28–March 4, 2022.

Gallagher, K.H., H. Lynch, and **M. Dinniman**, *Pygoscelis* penguin colony locations along the West Antarctic Peninsula could be driven by high retention and accumulation of simulated krill, 10th SCAR Open Science Conference (virtual), August 1–10, 2022.

Hancock, A., M. Williams, **E. Hofmann**, S. Henley, and S. Moreau, The Southern Ocean Observing System: Supporting the Community with Networks and Tools, oral presentation, 10th SCAR Open Science Conference (virtual), August 1–10, 2022.

Hofmann, E.E., Change to Change the Chesapeake, invited oral presentation, Maya Lin Exhibition Program, Virginia Museum of Contemporary Art, Virginia Beach, VA, July 7, 2022.

Hofmann, E.E., Ross Sea and Networks, invited oral presentation, Ross Sea Planning Workshop, Boulder, CO, October 3-5, 2022.

Hofmann, E.E., Southern Ocean Observing Systems, oral virtual presentation, Southern Ocean Prediction Session, Ocean Prediction Decade Collaborative Center Kick-off Virtual Meeting, January 11–12, 2023.

Hofmann, E.E., Overview on how biota/ecosystems respond/contribute to change, Committee on Future Direction for Southern Ocean and Antarctic Nearshore and Coastal Research, National Academies Community Workshop, Washington, DC, February 9–10, 2023.

Hofmann, E.E., M.R. Mulholland, **J.M. Klinck**, M. Echevarria, E. Perez-Vega, and J.B. Chrabot, *Margalefidinium polykrikoides* Blooms in the Lower Chesapeake Bay: Tradeoffs Between Physical Forcing and Biological Potential, poster presentation, Fall AGU Meeting, Chicago, IL, December 11-15, 2022.

Hofmann, E.E., **J.M. Klinck**, K.C. Filippino, T. Egerton, L.B. Davis, M. Echevarría, E. Pérez-Vega, and M. Mulholland, Understanding Controls on *Margalefidinium polykrikoides* Blooms in the Lower Chesapeake Bay, Ocean Sciences Meeting 2022 (virtual), February 28–March 4, 2022.

Hofmann, E.E., **J.M. Klinck**, K.C. Filippino, T. Egerton, L.B. Davis, M. Echevarría, E. Pérez-Vega, and M. Mulholland, Understanding Controls on *Margalefidinium polykrikoides* Blooms in the Lower Chesapeake Bay, oral presentation, Chesapeake Community Research Symposium 2022, Annapolis, MD, June 6–8, 2022.

Hudson, K., M. Oliver, J. Kohut, J. Cohen, **M. Dinniman**, M. Cimino, **J. Klinck**, H. Statscewich, K. Bernard, and W. Fraser, Subsurface eddy facilitates retention and increases particle delivery of simulated diel vertical migrators in a biological hotspot, Ocean Sciences Meeting 2022 (virtual), February 28–March 4, 2022.

Graduations

González Díaz, M., M.S., "Atlantic Surfclam (*Spisula solidissima*) Population Demographics and Distribution Along the Middle Atlantic Bight", December 2022, Advisor: J.M. Klinck.

Martin, D., M.S., "Using Stock and Flow Modeling to Address Knowledge Gaps in Marine Plastic Pollution Data", May 2022, Advisor: H-P. Plag.

Hudson, K., M. Oliver, J. Kohut, **M. Dinniman**, **J. Klinck**, C. Moffat, H. Statscewich, K. Bernard, and W. Fraser, A recirculating eddy promotes subsurface particle retention in an Antarctic biological hotspot, Ocean Sciences Meeting 2022 (virtual), February 28–March 4, 2022.

Klinck, J.M., Assessing economic impacts of offshore wind energy development on the US commercial surfclam fishing industry, Department of Ocean & Earth Sciences Spring Seminar Series, Old Dominion University, Norfolk, VA, April 14, 2022.

Kohut, J., H. Statscewich, H. Simmons, **J. Klinck**, **M. Dinniman**, K. Bernard, M. Oliver, and W. Fraser, A purpose-built integrated ocean observatory captures physical mechanisms driving spatial and inter-annual variability within an Antarctic coastal canyon, Ocean Sciences Meeting 2022 (virtual), February 28–March 4, 2022.

Park, K., I. Federico, E. Di Lorenzo, **T. Ezer**, K. M. Cobb, G. Coppini, and N. Pinardi, Timing and regional dynamics of extreme water level drivers in the U.S. southeast coast, Ocean Sciences Meeting 2022 (virtual), February 28–March 4, 2022.

Piñones, A., K. Bernard, **M. Dinniman**, D. Donoso, and P. Amador, Following the pathways of intrusions of Circumpolar Deep Water into a coastal embayment of the South Shetland Islands, using observations and ocean modeling, 10th SCAR Open Science Conference (virtual), August 2022.

Updyke, T.G., H. Roarty, M. Smith, and L. Nazzaro, Implementation of Quality Flags in the Processing of High Frequency Radar Surface Current Data, MTS/IEEE Oceans Conference, San Diego, CA, September 2021.

Wang, X., C. Moffat, **M. Dinniman**, **J. Klinck**, D. Sutherland, and B. Aguiar-Gonzalez, Variability and Dynamics of Along-Shore Exchange on the West Antarctic Peninsula Continental Shelf, Ocean Sciences Meeting 2022 (virtual), February 28–March 4, 2022.

Washington, K., S. Dangendorf, **T. Ezer**, and S. Clayton, Analysis of tidal range variability across the United States, Ocean Sciences Meeting 2022 (virtual), February 28–March 4, 2022.

Appointments

Ezer, T. and X-H Wang (Australia) were nominated as co-chairs of the International Workshop on Modeling the Ocean (IWMO) organization (http://www.ccpo.odu.edu/POMWEB/meetings.htm).

Publications

Dai, M., J. Su, Y. Zhao, **E.E. Hofmann**, Z. Cao, W.-C. Cai, J. Gan, F. Lacroix, G.G. Laruelle, F. Meng, J.D. Müller, P.A.G. Regnier, G. Wang, and Z. Wang. 2022. Carbon fluxes in the coastal ocean: Synthesis, boundary processes and future trends, *Annual Reviews Earth and Planetary Sciences*, 50, doi.org/10.1146/annurev-earth-032320-090746.

Dinniman, M.S., P. St-Laurent, K.R. Arrigo, **E.E. Hofmann**, and G.L. van Dijken. 2023. Sensitivity of the relationship between Antarctic ice shelves and iron supply to projected changes in the atmospheric forcing, *Journal of Geophysical Research*, 128, e2022JC019210, doi:10.1029/2022JC019210.

Ezer, T., 2023. Sea level acceleration and variability in the Chesapeake Bay: past trends, future projections, and spatial variations within the Bay, *Ocean Dynamics*, 73(1), 23-34, doi:10.1007/s10236-022-01536-6.

Ezer, T., 2022. A demonstration of a simple methodology of flood prediction for a coastal city under threat of sea level rise: the case of Norfolk, VA, USA, *Earth's Future*, 10(9), doi:10.1029/2022EF002786.

Ezer, T., 2022. Sea level variability in the Gulf of Mexico since 1900 and its link to the Yucatan Channel and the Florida Strait flows, *Ocean Dynamics*, 72(11-12), 741-759, doi:10.1007/s10236-022-01530-y.

Ezer, T. and S. Dangendorf. 2022. Spatiotemporal variability of the ocean since 1900: Testing a new approach using global sea level reconstruction, *Ocean Dynamics*, 72(1), 79-97, doi:10.1007/s10236-021-01494-5.

Ezer, T. and S. Dangendorf. 2022. The impact of remote temperature anomalies on the strength and position of the Gulf Stream and on coastal sea level variability: A model sensitivity study, *Ocean Dynamics*, 72(3-4), doi:10.1007/s10236-022-01500-4.

Ezer, T., S. Henderson-Griswold, and **T. Updyke**. 2022. Dynamic observations in the Hampton Roads region: how surface currents at the mouth of Chesapeake Bay may be linked with winds, water level, river discharge and remote forcing from the Gulf Stream, *OCEANS 2022, Hampton Roads,* pp. 1-5, IEEE. doi:10.1109/OCEANS47191.2022.9977092.

Goetz, K.T., **M.S. Dinniman**, L.A. Huckstadt, P.W. Robinson, M.R. Shero, J.M. Burns, **E.E. Hofmann**, S.E. Stammerjohn, E.L. Hazen, D.G. Ainley, and D.P. Costa. 2023. Seasonal habitat preference and foraging behavior of post-moult Weddell seals in the western Ross Sea, Royal Society Open Science, 10, 220500, doi:10.1098/rsos.220500.

Hudson, K., M.J. Oliver, J. Kohut, **M.S. Dinniman**, **J.M. Klinck**, M.A. Cimino, K.S. Bernard, H. Statscewich, and W. Fraser. 2022. A subsurface eddy associated with a submarine canyon increases availability and delivery of simulated Antarctic krill to penguin foraging regions, *Marine Ecology Progress Series*, 702, 105-122, doi:10.3354/meps14211.

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Hudson, K., M.J. Oliver, J. Kohut, J.H. Cohen, **M.S. Dinniman**, **J.M. Klinck**, C.S. Reiss, G.R. Cutter, H. Statscewich, K.S. Bernard, and W. Fraser. 2022. Subsurface eddy facilitates retention of diel vertical migrators in a biological hotspot, *Journal of Geophysical Research*, 127, e2021JC017482, doi:10.1029/2021JC017482.

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Kaeppler, S.R., E.S. Miller, D. Cole, and **T. Updyke**. 2022. On the use of high frequency surface wave oceanographic research radars as bistatic single frequency oblique ionospheric sounders, *EGUsphere*, 1–23.

Knutson, T.R., J.J. Sirutis, M.A. Bender, **R.E. Tuleya**, and B.A. Schenkel. 2022. Dynamical downscaling projections of late twenty-first-century U.S. landfalling hurricane activity, *Climatic Change*, 171(28).

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Newman, L., A.M. Hancock, **E. Hofmann**, M. Williams, S. Henley, S. Moreau, P. Bricher, and Others. 2022. The Southern Ocean Observing System 2021–2025 Science and Implementation Plan. DOI: 10.5281/zenodo.6324359.

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Sedwick, P.N., B.M. Sohst, C. O'Hara, S.E. Stammerjohn, B. Loose, **M.S. Dinnman**, N.J. Buck, J.A. Resing, and S.F. Ackley. 2022. Seasonal dynamics of dissolved iron on the Antarctic continental shelf: Late-fall observations from the Terra Nova Bay and Ross Ice Shelf polynyas, *Journal of Geophysical Research*, 127, e2022JC018999, doi:10.1029/2022JC018999.

Smith, M.J., **T. Updyke**, and S. Haines. 2022. October. Open-source software to support high frequency radar data analysis and quality control, *OCEANS 2022, Hampton Roads*, pp. 1-4. IEEE. doi:10.1109/OCEANS47191.2022.9977323.

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Wang, X., Z. Zhang, **M.S. Dinniman**, P. Uotila, X. Li, and M. Zhou. 2023. The response of sea ice and high-salinity shelf water in the Ross Ice Shelf Polynya to cyclonic atmospheric circulations, *The Cryosphere*, 17, 1107-1126, doi:10.5194/tc-17-1107-2023.

LARRY P. ATKINSON ENDOWED SCHOLARSHIP

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Center For Coastal Physical Oceanography (CCPO) and Institute for Coastal Adaptation & Resilience (ICAR) Virtual Seminar Series

FALL 2023 SCHEDULE

September 11	**Matthew Nowlin,** *College of Charleston*
September 18	**Erin Meyer-Gutbrod,** *University of South Carolina*
September 25	**Elspeth McMahon,** *Old Dominion University*
October 2	**Cristina Archer,** *University of Delaware*
October 16	**Glen Gawarkiewicz,** *Woods Hole Oceanographic Institution*
October 23	**Siddharth Narayan,** *East Carolina University*
October 30	**Daniel McLaughlin,** *Virginia Tech*
November 6	**Erin Seekamp,** *North Carolina State University*
November 13	**Jessica Whitehead,** *Old Dominion University*

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