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14. ABSTRACT
The American Meteorological Society's Project Ocean teacher professional development program promotes the scientific literacy of K-12 teachers and students by improving the physical oceanography background of in-service teachers. During the 2020-23 award period this was accomplished through 5-week summer courses fully offered to 38 teachers, with residence workshops at Washington College, and including course development and instruction by a U.S. Naval Academy professor. Project participants peer-trained 462 educators using significantly-revised course modules and other activities, and received graduate credit for full program participation. Past project alumni served as mentors for other AMS courses.

15. SUBJECT TERMS
physical oceanography, ocean, K-12, precollege, teacher professional development, training, United States Naval Academy, graduate course, Washington College, Pennsylvania Western University

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Project Ocean Final Report

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LONG-TERM GOALS

Project Ocean is designed to develop and deliver peer-led learning experiences and instructional resource materials to in-service, precollege teachers nationwide on selected topics in physical oceanography. Project Ocean is the next generation of the Maury Project, an exemplary graduate-level teacher professional development (PD) program offered since 1994. Project Ocean is designed to (1) provide training for up to 24 master teachers per year in a summer workshop-based course, and (2) develop quality instructional resource materials primarily for course instruction and post-course peer training. By providing intensive teacher PD using U.S. Navy expertise and content that participants take to their classrooms and local communities, Project Ocean assists ONR with its five STEM priorities to Inspire, Engage, Educate, Attract & Employ, and Develop & Retain, as outlined in *Naval STEM Strategy*. Project Ocean increases teacher and student participation, contains hands-on and meaningful learning experiences that support the ONR K-12 focus of "learning by doing," increases reach and impact of the U.S. Navy, and reaches out to the Nation's underserved populations.

OBJECTIVES

- Train up to 68 precollege teachers in physical oceanography topics in a 5-week course that includes an intensive, in-person, one-week workshop held in summer 2021 and summer 2022 at Washington College in Chestertown, MD. The workshop will be led by a faculty member from the U.S. Naval Academy, in collaboration with Washington College, California University of Pennsylvania/Pennsylvania Western University, and AMS project staff. The workshop will include on-site time at USNA, as well as potential instruction by other USNA faculty in years 2-3.
- Form a program for several weeks of online Project Ocean summer course study to help prepare teachers for and support the in-person workshop. The Cal U/PennWest instructor and the course learning management system are essential to implementation of the online components of the course. The Cal U/PennWest instructor will collaborate with a team to update course modules.
- Significantly revise, by adding updated scientific examples and forming NGSS linkages, and disseminate instructional resource modules on selected oceanographic topics for use by Project Ocean teacher participants and those attending the peer-training sessions the participants conduct.

- Enable Project Ocean alumni to take on leadership roles in AMS DataStreme distance-learning teacher professional development programs for up to 200 teachers annually, which focus on oceanography, water, and climate in the Earth system.
- Support the Project Ocean alumni who will conduct peer-led training sessions for 650-700 teachers during the period of the project.
- Conduct an annual leadership workshop for Project Ocean (and formerly Maury Project) alumni who serve DataStreme Ocean and Earth's Climate System course Mentor Teams.

In addition, the project anticipates that one consequence of the foreseen oceanographic and pedagogical knowledge gains of the teacher participants due to the project's activities will be to encourage precollege students, including those underrepresented in STEM, to consider pursuing careers in science and engineering. *Note:* This potential impact of the project is not measurable due to constraints in obtaining student data longitudinally from the precollegiate workshop participants. We do however, collect demographic data on the school populations overall.

APPROACH

There are three major components to this program: an annual summer course for precollege teachers, the production of instructional resource materials for teacher professional development, and the peer-training of additional teachers. The Project Ocean summer graduate credit course includes a one-week face-to-face workshop in the Maryland Chesapeake Bay area (Washington College in Chestertown, MD, with on-site time at USNA). There are also several weeks of online study offered through Cal U's Global Online Platform, which merged with two other universities on 7/1/22 to be the Pennsylvania Western University - PennWest Global Online platform. The in-person portion of the course has been led by a USNA faculty member Dr. Joseph Smith, supported by an ONR MIPR.

Project Ocean participants completing all course requirements, including one-week workshop attendance, supporting online coursework, and the conduct of peer-training workshops, earn three graduate-level credits through Cal U/Penn West. The Project Ocean course can be applied toward the university post-baccalaureate DataStreme certificate program. Project Ocean can also be used as a requirement toward the Certified AMS Teacher (CAT) certification program.

An important part of Project Ocean is the significant revision of the course modules used in course study and post-course peer-training sessions. Seven course modules have been modified to align with Next Generation Science Standards and Ocean Science Literacy Principles. There is more information on the peer-training component below.

WORK COMPLETED

Following significant course development and a limited pilot offering of the course to 2 participants (with prior Project Ocean relationship) during the pandemic year, the full Project Ocean course with the one-week workshop component was offered in summers 2021 and 2022. There were 16 teacher participants in 2021, as it was the initial offering at Washington College with pandemic-related safety concerns still present. In 2022, 22 teachers (21 U.S. teachers and 1 Canadian teacher supported by the Canadian Meteorological and Oceanographic Society) participated in the course. For the 37 U.S. summer 2021 and summer 2022 participants combined, demographic data is in Table 1.

Table 1 - Summer 2021 and 2022 Participant Institution Demographics

Project Ocean Course Year (n)	U.S. States	Locality	Public/ Private Schools	Grades Levels	Aver. % of Under-represented Students	Title I Schools
2021 (16)	AL, AZ, CO, IN, MN, MT, NE, NY(3), SC, TX(3), VA(2)	rural(4), town(4), suburb(4), city(4)	16	6-8(3), 9-12 (10), combo 6-8/9-12(3)	48%	13
2022 (22, 21 U.S. and 1 Canada)	AR, CA(2), CNMI, GA, IL, KS, MA, ME, MO, NC, NY(2), OH, OK, PA(2), TX(2), VA, VT	rural(9), town(3), suburb(7), city (2)	19/2	3-5(1), 6-8(7), 9-12(11), combo 6-8/9-12(1), K-12 (2)	25%	12

Progress during the full award period included development of 7 Project Ocean modules: Wind Driven Ocean Circulation, Geostrophic Flow, and Oceanic Gyres; Density-Driven Ocean Circulation; Ocean Tides; Deep Ocean and Shallow Water Waves; Wind-Driven Ocean Circulation, Ekman Transport, and Coastal Upwelling; El Niño ~ La Niña; and Sea Level Change. All seven modules form linkages with the Project Ocean Understandings document, National Oceanic and Atmospheric Administration (NOAA) Ocean Literacy Principles, and the Next Generation Science Standards (NGSS) K–12 science content standards. These modules were used within the Project Ocean course and post-course peer training. The summers 2021 and 2022 participants conducted peer training sessions that drew from module content, and also other demos and labs used within the Project Ocean course.

RESULTS

Conclusions from External Evaluator Dr. Elizabeth A Day (with minor updates from AMS staff)

All information and data collected for this final evaluation indicate that the project team continued to progress in their development, implementation, and plan for future Project Ocean offerings, despite not being able to offer the full course in summer 2020. The team extensively revised seven Project Ocean modules during the award period, and made linkages to NGSS and Ocean Literacy Principles and the Project Ocean Understandings document. The team administered a pedagogical survey in both summers, and also a cognate quiz. Based on Item analysis, the quiz underwent revision for summer 2022 based on a detailed summer 2021 analysis. Analysis of subsequent course question performance will drive future revisions of this tool.

Cognate pre/post: For the summer 2021 and 2022 Project Ocean courses, participants completed pre/post cognate tests. The results are presented in the table below; both summers saw statistically significant increases in participant content knowledge.

Table 2 - Cognate Pre/Post Results

course year (n)	# of test questions	Pre-test mean, standard dev., & range	Post-test mean, standard dev., & range	Increase and significance
2021 (16)	26	mean=15.75 (60.57%) standard deviation=3.32 range of 12 (46.15%) - 22 (84.62%)	mean= 21.81 (83.88%) standard deviation=2.71 range of =15 (57.69%) - 26 (100.00%)	+6.06 pts (23.31%) significant at p=0.01 level
2022 (22, 20)	26	mean=13.05 (50.19%) standard deviation=4.39 range of 6 (23.08%) - 24 (92.31%)	mean=18.62 (71.62%) standard deviation=4.70 range of 11 (42.31%) - 25 (96.15%)	+5.57 pts (21.42%) significant at p=0.01 level

Pedagogical pre/post: Overall, on the Project Ocean surveys, the greatest change from pre- to post- was on the Project Ocean pedagogy items where all items showed a significant pre to post increase in mean ratings for both the summer 2021 and 2022 courses. Additionally, six (summer 2021) and seven (2022) of nine confidence items showed a significant pre- to post- increase. Two of the items that did not show change exhibited very high scores on the pre-test, thus the lack of difference could be due to a ceiling effect. The least change occurred on the motivation/aspiration items. Participants rated their motivation/aspiration very high on the pre- and post- survey items. Again, the possibility of a "ceiling effect" with these items is very likely.

Residence Week Workshop survey: In summer 2021, of the 12 Course Content items, the mean ratings by participants exceeded 4.50 (Very Good) for all items. In 2022, of 12 Content items, the mean ratings by participants exceeded 4.50 (Very Good) for nine items and were in the "Good" range and exceeded 4.0 for the other three items.

In 2021, of the four (4) Teacher Break Out Groups items, the mean ratings by participants exceeded 4.40 (Very Good) for all items. Additionally, on all items at least 13 (86.7%) of respondents selected "Very Good" or "Excellent". In 2022, of the four (4) Teacher Break Out Groups items, the mean ratings by participants exceeded 4.45 (Very Good) for all items.

Most participants (31; 93.9%) indicated that the course increased their awareness of the US Navy/Naval Academy either "somewhat" or "A great deal".

Most participants (29 over the two summers; 90.6%) found having an integrated Learning Management System (LMS (e.g., D2L)) to support Project Ocean as "Useful" or "Very Useful"."

Nearly all 2021 and 2022 participants (32; 97.0%) rated the Project Ocean Residence Workshop experience compared to other professional development experiences as "Somewhat better than" or "Much better than". Nearly all participants (32; 97.0%) rated the workshop as "Very Good" or "Excellent" on educational content. In addition, all (33; 100.0%) participants rated the Professionalism

of staff during the Project Ocean Residence Workshop as “Excellent”.

Most (30; 90.9%) participants over the two summer courses expressed that they are “Extremely Likely” to recommend Project Ocean to other teachers.

Peer Training Session Surveys: In the peer-training they conduct, 97% of 2021 and 2022 Project Ocean participants (1 neutral response) reported that educators in their peer-training session responded positively to the usefulness of the physical oceanography topic presented and 73% of those using modules in their peer training reported that educators responded positively to the usefulness of the modules (with the remaining having a neutral response).

IMPACT/APPLICATIONS

Project Ocean course participants are committed to offering 1-2 single-topic training sessions lasting from 1-2 hours each, primarily directed toward precollege teachers. One workshop is required if the initial peer-training session has an audience greater than 5; 2 workshops are required in cases of lower attendance. Table 1 below lists workshops conducted by the 2019, 2021, and 2022 workshop groups (the 2020 break due to the pandemic).

Table 3 - Project Participants and Peer-Training Workshop Impact

Year	Participants	# of Peer-Training Workshops	# Trained
2019	24	39	454
2020	*limited pilot offering due to pandemic*		
2021	16	15	172
2022	22	16	177

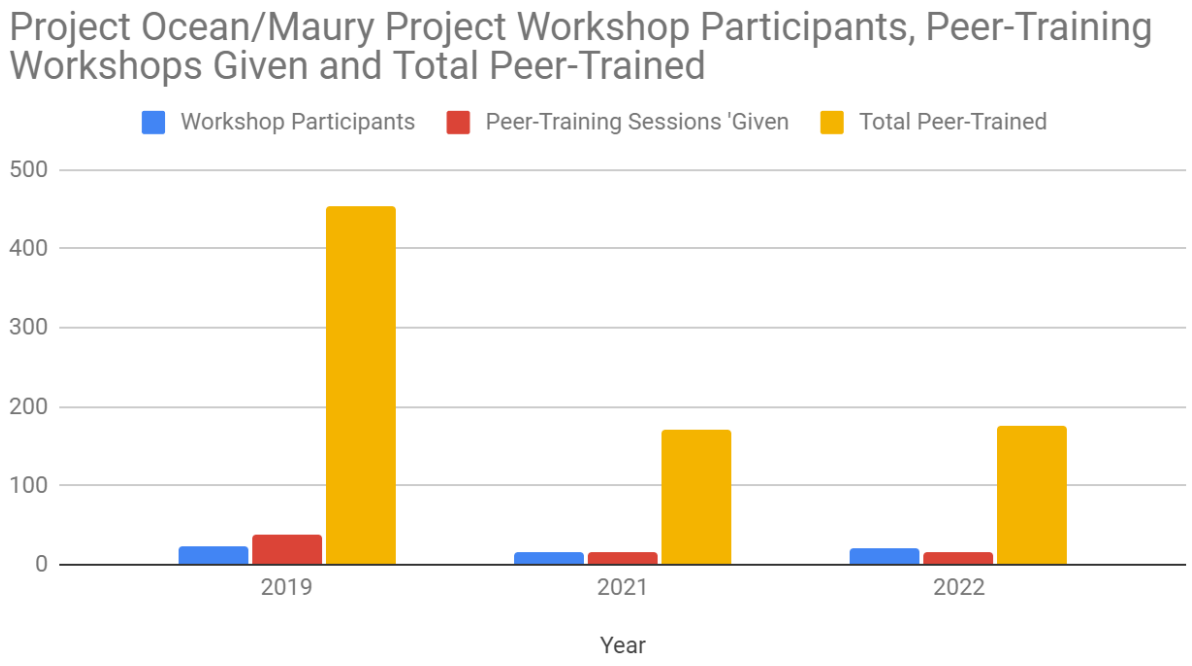

Figure 1 - Peer Training Impact

The 2019 alumni have so far conducted 39 workshops for 454 persons (mostly precollege teachers). The 2021 group has conducted 15 workshops for 172 persons, and 16 summer 2022 participants conducted 16 workshops reaching 177 educators. During the current award period, a 2018 course alum also conducted two workshops for 35 educators.

There have been 643 Project Ocean/Maury Project participants since 1994, who have conducted 1155+ peer-training workshops for an estimated 14,850 persons, mostly K-12 teachers. Note that there are records since 2002 on the number of attendees of the peer-training workshops; 1994-2001 data was derived using the average number of peer-trained participants/year from 2002-2017.

TRANSITIONS

DataStreme PD courses (Ocean, Earth's Climate System, and Atmosphere courses) are led by the Cal U/PennWest course instructor with assistance by 1-3-member Mentor Teams. Mentor teams include an experienced teacher with AMS programs, including those with successful experience in Project Ocean/Maury Project. During the fall 2020 - spring 2023 semesters, Mentor Teams helped 532 teacher participants complete DataStreme courses as a whole. There were 348 teachers completing Ocean and ECS courses. In the most current semesters covered by the award (fall 2022 and spring 2023):

Fall 2022 DataStreme Mentor Team members -
Ocean – of 13 total members, 7 are Project Ocean/Maury Project alumni and 1 is a Project Ocean consultant/workshop presenter
Earth Climate System – of 18 total members, 5 are Project Ocean/Maury Project alumni
Atmosphere – of 18 total Mentor Team members, 5 are Project Ocean/Maury Project alumni

Spring 2023 DataStreme Mentor Team members -
Ocean – of 10 total members, 7 are Project Ocean/Maury Project alumni 1 is a Project Ocean consultant/workshop presenter
Earth Climate System – of 18 total members, 6 are Project Ocean/Maury Project alumni
Atmosphere – of 18 total Mentor Team members, 7 are Project Ocean/Maury Project alumni

RELATED PROJECTS

As an example of leveraging, the AMS Ocean Studies introductory college-level oceanography course, built on experiences gained in Project Ocean/Maury Project and DataStreme Ocean, has been introduced to more than 200 institutions (mostly colleges/universities, including 77 minority-serving institutions, as defined by Federally-designated institutions and others having about 25% or more of their students identifying with underserved racial/ethnic groups in STEM), impacting about 41,000 students, including about 6000 during the award period. Faculty offering the course at MSIs have attended AMS and partner-lead PD workshops in oceanography, climate science, and paleoclimate. AMS Ocean Studies would not exist without the experiences gained from Project Ocean and DataStreme Ocean, including materials development. A major benefit of AMS Ocean Studies is that it reaches pre-service precollege teachers.

In terms of Project Ocean sustainability, AMS was awarded a new one-year grant (7/1/2023 - 6/30/2024) to cover the summer 2023 course offering. This award is being led by PI and new AMS Education Program Dr. Aaron Price, who has an extensive educational and scientific background. Additionally, following submission of a white paper to the ONR STEM program in April 2023, AMS was invited to submit a full proposal. Through these avenues, we are working to sustain and expand

upon the long-term success of Project Ocean with new partners and new teachers to reach, especially those teaching in underserved communities.

PUBLICATIONS
Over the full award period:

Modules:
Wind Driven Ocean Circulation, Geostrophic Flow, and Oceanic Gyres; Density-Driven Ocean Circulation; Ocean Tides; Deep Ocean and Shallow Water Waves; Wind-Driven Ocean Circulation, Ekman Transport, and Coastal Upwelling; El Niño ~ La Niña; and Sea Level Change were published to the website
https://www.ametsoc.org/index.cfm/ams/education-careers/education-program/k-12-teachers/project-ocean/training-opportunities/project-ocean-peer-led-training/project-ocean-peer-training-resources/
during the award period.

Conference presentations (2020):
Ripollone, D., W. Abshire, and M.J Passow, (2020) Distinguish Yourself in Earth Science Teaching: The New Certified AMS Teacher (CAT) Program, Virtual Earth Educators Earth Educators' Rendezvous. Oral. [published]

Abshire, W., (2020) Education Program Opportunities for Teachers, Virtual Michigan Earth Science Teachers Association meeting. Oral. [published]

Conference presentations (2021):
Abshire, W., Blair B.A., and Mills E.W., (2021) AMS Education Activities in Support of Earth Science Literacy: Thirty Years, Fifty Semesters, COVID Adaptations and More!, AMS Virtual Annual Meeting, 30th Conf on Ed. Oral. [published]

Abshire, W. E.W. Mills, and C.M. Kauffman, (2021) American Meteorological Society and California University of Pennsylvania: Working Together to Offer Inspirational Rigorous Weather, Ocean and Climate Science Professional Development to Educators Nationwide, AGU Fall Meeting, Oral. [published]

Conference presentations (2022):
Schreiber-Abshire W., J.P Smith, J. Clark , and C.M. Kauffman (2022) The NEW Project Ocean Course and other AMS Professional Development Opportunities for K-12 Educators AMS Annual Meeting, Houston, TX, 31st Conf on Education, Oral. [published]

Stimach, A.E., L. Baugher, W. Schreiber-Abshire, and C.M. Kauffman, (2022) Demonstrating 3D Concepts in Earth Science through Active Learning, AMS Annual Meeting, Houston, TX, 31st Conf on Education, Oral. [published]

Schreiber-Abshire, W., E. Grow, C.M. Kauffman and A.E. Stimach, (2022) Making a Difference via the AMS Education Program: Opportunities to Support Educator Professional Development in Weather, Ocean, and Climate Science 10th Symposium on the Weather, Water, and Climate Enterprise, AMS Annual Meeting, Houston, TX, Oral. [published]

DeSchryver, S., J. I. Pullin, J. A. Yuhas, and W. Schreiber-Abshire, Update on the Certified AMS Teacher (CAT) Program and Other New Initiatives Involving the Board on Pre-College Education. AMS Annual Meeting, Houston, TX, 31st Conf on Education, Oral. [published]

Schulz. S., (2022) Bringing Oceans into the Physical Science Classroom. NSTA National Meeting, Houston, TX, Oral. [published]

Stimach, A.E., (2022) AMS Education Program Explores the Building Blocks of Understanding Pressure. NSTA National Meeting, Houston, TX; share-a-thon. [completed]

Abshire W. and E.W. Mills, (2022) American Meteorological Society Education Initiatives: Earth Science Literacy for All! EER National Meeting, Minneapolis, MN. [published]

Conference presentation (2023):
Abshire W., E.W. Mills, and B.A. Blair, (2023) Recent Evolution and Future Directions of AMS Education Program Teacher Professional Development Programs, AMS Annual Meeting, Denver, CO. [published]

HONORS/AWARDS/PRIZES
In addition to Project Ocean/Maury Project alumni peer-training activities and DataStreme Mentor Team participation, there are notable examples of participants continuing their broader leadership roles in STEM education. Thirteen (13) Project Ocean/Maury Project alumni earned the AMS DataStreme Certificate through Cal U (now PennWest) for completing three AMS courses, and 16 alumni have become Certified AMS Teachers (since 2020).