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Pathways to Ocean Science Careers: Which Significant Life Experiences Play a Key Role?

RESEARCH AND EVALUATION

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ABSTRACT

Research suggests that life experiences are connected to a person's career in STEM. Despite this, the pathways to careers in ocean science are less studied. Additionally, while there is effort to increase opportunities for underrepresented populations in STEM, little research has been done to reflectively look at the perspective of someone working in the ocean science field. This pilot study examined the life experiences leading to a range of ocean science careers, to uncover which significantly impacted participants' choices to pursue a career in this field, and any barriers participants encountered that may affect representation. Study results indicated that 60% of respondents selected their career by the completion of high school, highlighting the importance of ocean literacy exposure in K-12 classrooms. Additionally, the survey indicated structured and unstructured learning experiences as highly influential. Finally, barriers to the field of ocean science were identified such as gender, race, and economic disparities.

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INTRODUCTION

Human population and anthropogenic interactions with the natural world are increasing, causing environmental issues (increasing global temperatures, severe drought, sea level rise, etc.) to increase at a rapid rate (Steffen et al. 2011; Fleming et al. 2019). To address the needs of the future, workforce development must focus on increasing STEM professionals (Cook et al. 2022) not only in number, but also in diversity, to adequately address the issues that our natural environment and population will face in the future (Rivera et al. 2022; Windleharth et al. 2023).

One aspect of the STEM workforce are careers focused on the oceans, specifically how oceans are impacted by these environmental issues and how these impacts will affect humans (Nash et al. 2022). To address these specific STEM workforce needs, ocean literacy is needed for all. Ocean literacy is defined as

> an understanding of the ocean's influence on you – and your influence on the ocean. An ocean-literate person understands the essential principles and fundamental concepts about the ocean, can communicate about the ocean in a meaningful way, and is able to make informed and responsible decisions regarding the ocean and its resources (NOAA 2024, p. 2)

We need ocean literacy to "have a society that understands, values, and cares for the ocean" (Glithero et al. 2024, p. 10). Some authors have even suggested that ocean literacy in students is necessary for the ocean's future sustainability (Chen & Tsai 2016), or to "attract new talent into fields like marine science" (Tusan & Slown 2025). Previous ocean literacy research has focused on the outcomes of specific programs (e.g., Lambert 2007; Bischoff et al. 2008; Mohr-Schroeder et al. 2014), but scant research has focused on the successful drivers toward a career in ocean sciences. This study aimed to identify any common pathways or entry points to a career within ocean sciences. Additionally, we aimed to understand how people's life experiences may have encouraged them to pursue this career pathway, as a means to identify best practices for ocean educators, informal education organizations, and institutes of higher learning to pursue to increase these pathways, and foster ocean literacy, especially for those from underrepresented populations within the field.

DIVERSITY

A nested problem within the need for additional ocean science professionals is the need to recruit a diverse workforce. Diversity in the field of ocean science is lacking (Johri et al. 2021), and this lack of diversity extends throughout other STEM fields with statistics demonstrating men are more likely to pursue careers in STEM than their female counterparts (Perdrial et al. 2023; Rhodes-Ondi & Ghardiri 2019). If we are to address the needs of the future, we must also consider the need to develop ocean literacy within all populations. Increasing the diversity of those that have ocean literacy may lead to an increased diversity of the workforce, which could help in adequately addressing the issues that our natural environment and population will face in the future (Cheruvelil et al. 2014; Rivera et al. 2022; Yang et al. 2022).

Several barriers to diversification of STEM and ocean science career pathways have been identified in the literature including lack of mentorship and professional development, as well as financial barriers (Johri et al. 2021). Additionally, impacts from a student's life experiences such as supportive parents, informal education experiences, and opportunities to pursue project-based learning in school can impact a student's intention to pursue a career in STEM (Sahin et al. 2018). These barriers may also affect early career professionals remaining in the field (Johri et al. 2021).

STEM organizations nationwide, including ocean science institutes, are putting great effort into increasing opportunities for people from underrepresented and historically excluded populations, and attempting to eliminate or bridge across possible barriers (Estrada et al. 2016). These opportunities include programs for the general public, recruiting undergraduate and graduate students, and even recruitment of faculty for the institute itself (Bevan et al. 2018; NASEM 2016). Despite these efforts, we understand little about how these efforts actually impact the pipeline of future ocean professionals.

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To address the need for an ocean literate, diverse workforce, ocean education programming has been offered both informally and to a lesser extent, formally. Traditionally, most research from this field has been constrained to a focus on short-term evaluation data, such as follow-up surveys and pre- and post-tests offered during programming (Chawla 2006). This allows environmental educators, funding agencies, and federal organizations to make decisions about the effectiveness of particular programs and how those programs impact ocean literacy and career interest but may limit assessment of long-term effects on participants. But how can environmental education providers understand the long-term impacts of their programming in inspiring people to pursue an ocean science career pathway? What are the experiences, or combination of experiences that are the most successful and impactful drivers to recruiting students into STEM, and more specifically the ocean sciences field (Sahin et al., 2018)? To do this, we suggest looking backwards to see what impacted people to get into and stay in the field.

THEORETICAL FRAMEWORK

To answer these questions regarding what influences a person's choice of career in STEM, examining life experiences may be key (Kier et al. 2013). Adults asked to reflect on the pathway to their current career often share important life events or moments that were meaningful to them (Snively 2018). These incidents can be referred to as "significant life experiences" (Tanner 1980; Chawla 1999, 2001). Significant life experiences (SLE) research provides an avenue for deeper understanding of the potential long-term effects of key events and experiences people encounter (Chawla 2006). While SLE research originated as qualitatively focused, specifically with interviews and deeper understanding of the emotional and interpretive side of a person's life experiences (Chawla 1999), this can limit research to smaller sample sizes due to its time-intensive practices. SLE research has evolved to also include quantitative surveys that allow researchers to reach a greater number of participants.

SLE studies conducted in the adjacent field of environmental education have typically focused on the influences of life events on building environmental behaviors (Chawla 1999; Stevenson et al. 2014; Li & Chen 2015), and activism within individuals (Tanner 1980). We found only one study focused specifically on career impacts, using SLE to study faculty within an environmental field to determine influences on that career path (Cagle 2018). No literature was discovered that focused on SLE and ocean science careers. Additionally, in our field, many marine science professionals anecdotally name their "flashbulb memory" or a short but inspirational moment (Brown & Kulik 1977, p. 74) that inspired their interest in ocean science, but those memories have not been documented formally or analyzed for commonalities.

Additionally, while there is a great effort to increase opportunities for underrepresented populations in STEM (Bevan et al. 2018; NASEM 2016), little to no research has been done to reflectively look at success stories from the perspective of someone working in the ocean science field. These previous life experiences (or combination of experiences) may lead us to understand which produces the greatest success, and this information could be beneficial across multiple perspectives including; informal educators, faculty mentoring and recruiting students, and funding agencies that offer internships and fellowships within ocean science. Ultimately, results could lead these groups to make data-based decisions regarding their education and outreach activities.

Therefore, our research focused on the significant gap regarding SLE and ocean sciences and utilized this framework similarly to how it has been used in the larger field of STEM (Maltese et al. 2014; MdBio Foundation 2015). Focusing on SLE and formative influences on choosing a career in ocean sciences could identify potential influences such as outdoor experiences, internships and job opportunities, books, personal connections, teachers, etc. (Tanner 1980). We proposed to examine the life experiences leading to a range of ocean science careers, to uncover which significantly impacted participants' choices to pursue a career in this field (Tanner 1980; Chawla 1999).

METHODOLOGY

For this study, we modified an existing survey, the 2015 STEM Education Survey (MdBio Foundation 2015) which aimed to determine the "catalysts that drove these professionals

to pursue a STEM career" (para. 4). We adapted the survey for our needs specific to ocean science, adding both select-response and constructed-response questions while taking into consideration findings from environmental education SLE work that suggested specific questions we could ask related to ocean science, such as outdoor experiences (Tanner 1980). The survey was crafted to assess two main research questions: (1) What are the common significant life experiences that lead to a career pathway in ocean science? and (2) Are the barriers noted in STEM studies similar to those seen for ocean science careers? The survey included 23 questions, with an expected completion time of 10–15 minutes. Questions ranged from demographic collection, to information regarding current position and highest degree earned, as well as length of time employed in the field. Additionally, participants were asked about their influences when deciding to pursue a career in ocean science, and which barriers, if any, they encountered. Prior to data collection, the survey was sent to experts in the fields of ocean science and STEM research for external review and validation. Finally, the survey instrument was submitted for IRB approval prior to any distribution. Participants provided implied consent to participate in the study before beginning the online survey.

DATA GENERATION

This pilot study focused on a research institute affiliated with a mid-Atlantic university where faculty, staff, and graduate students were targeted. Excluded from participation were individuals employed in careers that did not require work at an ocean science institution (i.e., university fundraising, finance, communications and marketing, sponsored programs). We estimate that of the approximately 500 faculty, staff and students at this institution, roughly 20% (n = 100) do not meet the survey requirements, leaving an eligible pool of respondents at 400. The Qualtrics survey was distributed across the institute-wide listserv and data was collected for approximately 1 month during the spring of 2023, with several additional reminder emails sent to encourage participation.

A total of 75 responses (20% of the eligible population) were collected from individuals employed in ocean science careers at the pilot survey institute (Table 1). Nearly three-quarters of respondents were under 50 years old (72%) and over half identified as women (64%). Respondents were 85% white, with 4% identifying as Hispanic or Latino ethnicity, 4% of respondents identified as Asian, 4% of respondents identified as multi- or mixed-race, and 3% of respondents preferred not to answer.

Based on demographic data provided by institute human resources, pilot study respondents were a representative subsample, with the exception of women who were overrepresented in the pilot study (64% of respondents vs. 52% of the institute population) and early career employees who were underrepresented in the pilot study (37% of respondents vs. 57% of the institute population). Additionally, demographic data provided by the institute only represented faculty and staff, while the survey pool also includes graduate students. At the survey institute, graduate students receive compensation in addition to coverage of their tuition and thus were included in the definition of being employed in an ocean science career. The collection of demographic data allowed for analysis aggregated by categories including gender, socioeconomics, ethnicity, race, etc. (Li & Chen 2015).

DATA ANALYSIS

Summary statistics were conducted on select-response survey questions to assess whether demographic data impacted respondents' career pathways and any experienced barriers. Constructed response questions were analyzed to determine commonalities in flash-bulb moments and significant life experiences as entry points to ocean science careers as well as timing of those decision points. Responses were also analyzed to determine commonalities in barriers experienced by those already employed in an ocean science career.

To code constructed response questions, both authors read and coded the first 25 responses. The responses were discussed and codes created to categorize responses. Each code was defined, and a code book was developed. After codes and code definitions were finalized for the first 25 responses, the two authors independently coded the remaining responses. To increase inter-rater reliability, we discussed our rationale for particular codes when there were discrepancies and brought our agreement to 100%. All codes were sorted for percentage of use.

DEMOGRAPHIC CATEGORY	PERCENTAGE OF PARTICIPANTS
Age	
21–29	35%
30–39	24%
40–49	8%
50–59	15%
60+	12%
No Response	1%
Gender	
Man	33%
Woman	64%
Non-binary	1%
No response	1%
Race/Ethnicity	
White	85%
Asian	4%
Hispanic/Latinx	4%
Multi/Mixed	4%
No Response	3%
Highest Degree Earned	
Bachelor's degree	28%
Master's degree	43%
Doctoral degree	29%
Years Employed	
5 or fewer	37%
6–10	16%
11–15	8%
16–20	9%
>20	29%

Table 1 Demographic summary of pilot study participants (*N* = 75).

RESULTS

Both quantitative and qualitative data was analyzed to better understand participants' pathways to careers in ocean science. Quantitative data analysis highlighted several key points from the pilot study. One of the most significant was related to the timing of these career decisions. Sixty percent of participants decided to pursue ocean science as a career pathway during their K-12 career, suggesting that formative experiences such as class activities, field trips, familial influence, and enrichment programs such as camps play a large role in influencing pathways. In addition, women were more likely to make this decision before graduating high school than their male counterparts. To further examine the timing of decision-making, we found that 82% of participants were pursuing a career in ocean science by the time they finished their undergraduate degree. This data suggests that the majority of individuals in the field of ocean science were influenced heavily by childhood and early adolescent activities.

Within the qualitative data, several themes emerged within both the flashbulb moments/ significant life experiences and barriers to a career in ocean science. Through pilot study participants' direct quotes, we ascertained a variety of life experiences influencing their interest in ocean sciences, as well as common barriers encountered which will be discussed in the following sections.

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FLASHBULB MOMENTS & SIGNIFICANT LIFE EXPERIENCES

Flashbulb moments can be surprising, brief in length, and have varying levels of inspiration (Brown & Kulik 1977). We found that flashbulb moments, while brief, are the one(s) that are most significant for individuals to begin pursuing a career pathway in ocean science, yet significant life experiences can be additive or repetitive experiences that further enriched or enhanced that desire. Examples of participants' flashbulb moments ranged from childhood adventures on the beach to inspiring courses within their grade school and undergraduate schooling. In the survey, respondents had the option to describe a specific flashbulb moment that was memorable to them and the majority (73%) did. Additionally, respondents were required to select up to three SLEs from a list of provided options (i.e., camps and classes, life/family event, current events/news).

To assist in understanding which categories of flashbulb moments and significant life experiences most commonly led to a career in ocean science, responses from the flashbulb moments were coded and subsequently sorted into four themes: intrinsic value, personal connections, structured learning experiences and unstructured learning experiences (Table 2). SLEs selected by participants were also sorted into the same four themes.

Responses in the intrinsic value theme, while not categorized as a specific moment or experience, represent a respondent's lifelong interest or affinity towards ocean science generated without being able to name a specific exterior influence. Respondents in this theme shared similar sentiments of "I've always loved the ocean" and "I've always wanted to be in this field." The personal connections theme included experiences gained from a personal encounter such as a family legacy career or an interaction with a teacher or mentor. The final two themes – structured and unstructured learning experiences – were generated from experiences that included a learning environment. Structured learning experiences were those that happened in formal education (K-12) or undergraduate research, internships, and ocean science themed camps and/or classes. The classes and camps mentioned by respondents ranged from experiences learning about the ocean in preschool to undergraduate-level courses. Some flashbulb moments shared were not even ocean-specific, such as a composting program started in a 3rd grade classroom that led to a love of all science, and transitioned to ocean science specifically later in life. For most though, it was the ocean specifically that drew them in. One respondent shared about a week-long summer course and a specific field experience being in knee deep marsh mud when they realized "this is what I want to do!" Others had impactful courses such as oceanography and marine biology in high school, or an undergraduate course on beaches and shoreline processes. One participant shared about a course that "just clicked with my brain and I hadn't realized that was something I could study."

Unstructured learning experiences were those that happened through a visit to an aquarium or science center, pop culture, current events, or life or family events. Life and family events included experiences at any point in time during the participant's life such as trips to the beach where "I would bring back home a bucket of sand with little clams in it." Some respondents shared specific family members that took them outdoors as a child for activities such as fishing and crabbing, whereas others described adolescent experiences during family vacations where they were awestruck by a marine creature on the beach. Visiting aquariums and science centers during adolescence was another commonly reported flashbulb moment. One participant shared that an "early childhood visit to aquariums where everything was huge and blue and wonderful" excited them about all they could learn about ocean science.

Looking specifically at the memorable, flashbulb moments that deeply inspired participants' interest in ocean science and encouraged them to pursue a career in ocean science, structured (41%) and unstructured (35%) learning experiences were most frequently named (Figure 1), with over three-quarters of responses falling into these two themes. The personal connection theme was the least reported by respondents (5%), and 19% of respondents provided a response suggesting their flashbulb moment arose from deriving intrinsic value from the experience (e.g. desire to make a significant impact).

In contrast to the flashbulb moments question which was open-ended, for significant life experiences, respondents were asked to select up to 3 significant life experiences from a pre-generated list that were most influential in their decision to pursue a career in ocean science (Table 3).

FLASHBULB MOMENTS		
THEME OR CODE	**TOTAL (%) (N = 64 CODES)**	**EXAMPLE PARTICIPANT QUOTES**
Theme 1: Structured Learning experiences	32 (50)	
Code 1a: Undergraduate research		My moment was being taught the impacts people have on valuable coastal resources that society depends on during an undergrad independent research project.
Code1b: Internships		Getting the right internship opportunity focused on marine science was the primary reason for moving towards a career in marine science.
Code 1c: Camps and classes		The experience of taking a week-long summer marine science course on the Eastern Shore of Virginia (now called Chincoteague Field Lab). I distinctly remember being out on the marsh in knee deep muck and saying – this is what I want to do!
Theme 2: Personal Connections	4 (6)	
Code 2a: Family legacy		My father worked in an aquarium, first as a diver and then on the maintenance team, when I was a child, and I got to run around behind the scenes with him on the weekends. I was always super fascinated in the ocean because of these experiences growing up...
Code 2b: Teacher or mentor		My direct supervisor was an incredible mentor. He provided professional development opportunities, let me cross train with other programs to build skills, trusted me to work independently, and truly valued his employees well being. He built strong relationships with local fishermen and created a robust monitoring program. Working with him helped inspire me to seek a career in coastal sciences.
Theme 3: Unstructured Learning experiences	28 (44)	
Code 3a: Visits to aquariums/science centers		Early childhood visit to aquariums where everything was huge and blue and wonderful. So much excitement and learning to be had!
Code 3b: Life/family events		A trip to the beach as a child when I would bring back home a bucket of sand with little clams in it.
Code 3c: Pop culture		Watching "Planet Earth," "Blue Planet," "Crocodile Hunter" and other television shows and films as a young child. I was always awestruck.
Code 3d: Current events		...the BP oil spill in the Gulf occurred and I did a science fair project on cleaning up the oil in 8th grade.

Table 2 Flashbulb moment codes grouped by theme.

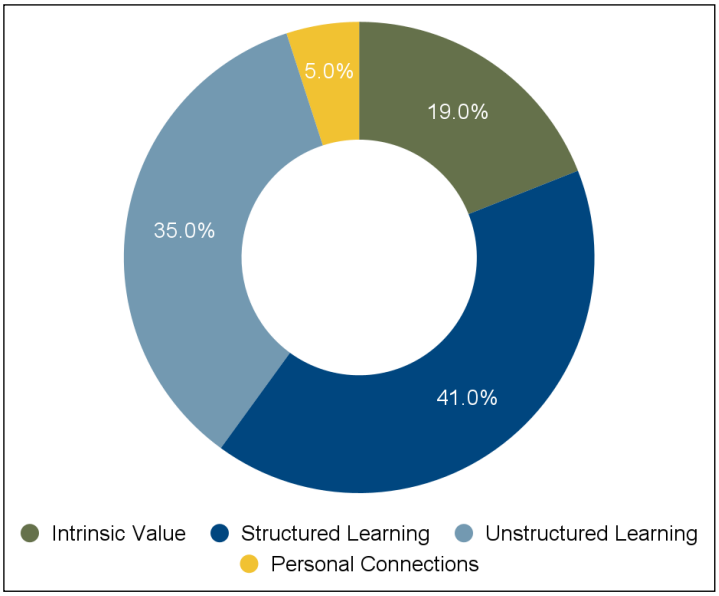


Figure 1 Flashbulb Moments Leading to Ocean Science Careers Grouped by Theme.

SIGNIFICANT LIFE EXPERIENCES LEADING TO A CAREER IN OCEAN SCIENCE (n = 205)	
Life/Family Event	17.6%
General Interest	14.1%
Aquariums & Science Centers	12.1%
Desire to make a significant impact	10.2%
Undergraduate Research	10.2%
Teacher/Mentor	8.8%
Specific Interest	8.3%
Camps & Classes	5.9%
Internship	3.9%
Job Prospects	2.9%
High School Research	2.4%
Family Legacy	2.0%
Current Events/News	1.5%
Family Pressure	0%
Financial Incentives	0%

Table 3 Significant Life Experiences Leading to Ocean Science Careers.

With this question, responses were more varied. In the case of significant life experiences, the themes of structured (22%) and unstructured (31%) learning experiences accounted for just over half of responses, while the intrinsic value theme represented the highest percentage of responses (36%) (Figure 2). There was also an increase in significant life experiences reported in the personal connections theme (11%).

Through the flashbulb moments shared by participants, key takeaways are the importance of structured and unstructured learning opportunities in kickstarting an individual's interest in the field of ocean science. After having a flashbulb moment, individuals may have pursued activities and explorations on their own to increase their intrinsic interest in the field. That being said, unstructured and structured learning opportunities continued to play a large role in the significant life experiences leading to careers in ocean science.

BARRIERS TO CAREERS IN OCEAN SCIENCE

Our second research question focused on whether the barriers from respondents in ocean science career fields aligned with the barriers identified in other STEM-related studies. As mentioned previously, a nested problem within pathways to careers in ocean science is the lack of diversity within the field (Johri et al. 2021). Despite efforts to increase diversity, specifically

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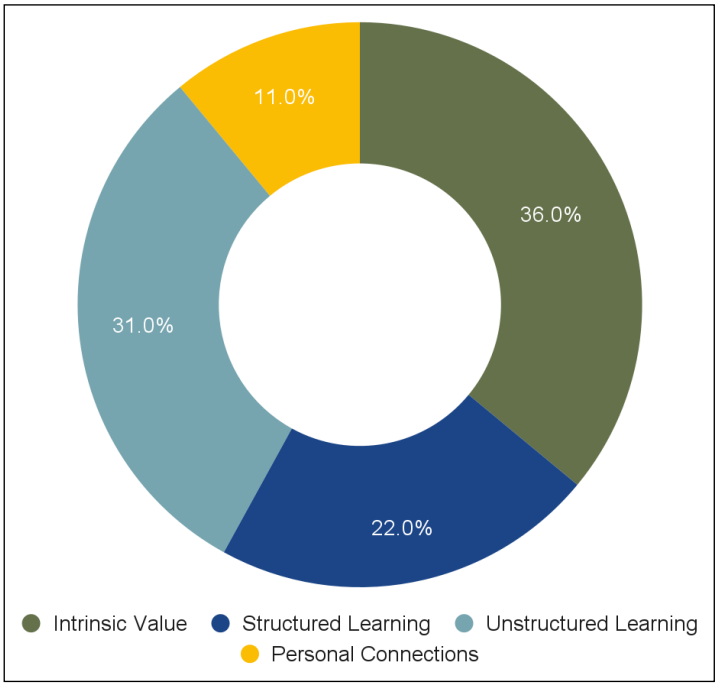


Figure 2 Significant Life Experiences Leading to Ocean Science Careers Grouped by Theme.

racial and gender diversity, there is still a need for more work on this front (Lewis et al. 2023). When comparing ocean sciences to other STEM fields, we questioned whether the barriers were alike, or if there were unique barriers associated specifically with ocean science. In STEM, the lack of gender and racial diversity has been noted due to lack of mentorship and professional development, as well as financial barriers (Johri et al. 2021). Additionally, life experiences such as lack of support from family members (Bueno et al. 2022) and lack of both formal and informal learning opportunities can increase barriers for particular populations within STEM (Houston et al. 2022).

Survey respondents were asked to what extent the following were barriers to their pursuit of an ocean science career; race/ethnicity, gender identity, socioeconomic status, lack of mentors and/or support, and lack of educational opportunities. Responses to these Likert scale questions are shown in Table 4, where each barrier is represented as its own question, and the total responses and percentage listed are indicative of the number and percent of participants who agreed or strongly agreed with the existence of that barrier for them.

Participants were also asked if there were additional barriers that impacted their pursuit of an ocean science career. Those responses were grouped into four broad themes – systemic issues, personal barriers, financial, and leadership and mentorship (Figure 3). We argue that several of these categories mirror the general barriers to STEM careers, but others such as personal barriers may extend the understanding of barriers specific to an ocean science career.

Systemic issues, defined here as those barriers that affect large populations of people, included topics such as white supremacy culture, gender identity, lack of educational experiences for ocean science in classrooms, and limited job opportunities in the field. These systemic issues face many that pursue both STEM and ocean science careers. Specific to gender, participants shared statements such as "being part of the LGBTQ+ community has sometimes felt like a barrier in my pursuit of an ocean science career". Other gender-specific barriers included uncertainties around housing during field experiences, assumptions about sexuality or legitimacy of identity, and microaggressions during field work and conferences.

TYPE OF BARRIER	TOTAL (%) N = 75
Race/Ethnicity	1 (13)
Gender Identity	4 (5.3)
Socioeconomic Status	6 (8)
Lack of mentors/support	6 (8)
Access to educational opportunities	7 (9.3)

Table 4 Barriers to Careers in Ocean Science: Participants who agree or strongly agree.

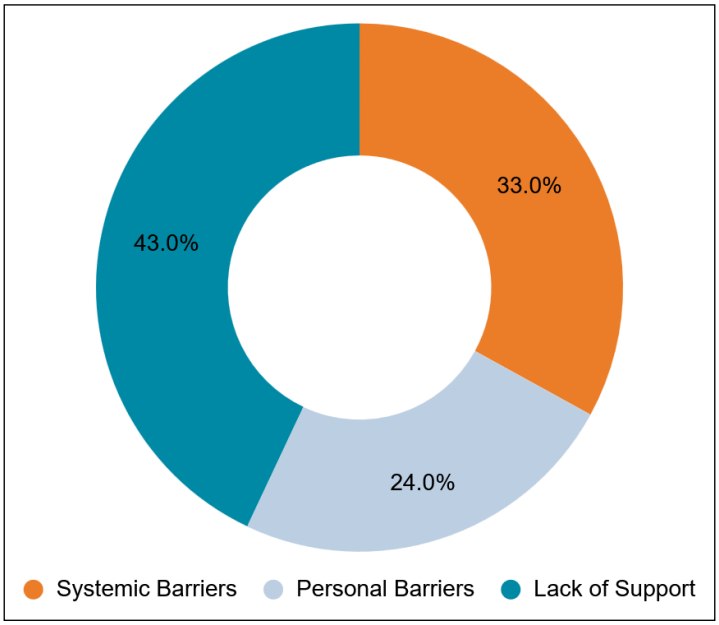


Figure 3 Barriers to an ocean science career grouped by theme.

Additionally, some respondents had been in the field for many years and reflected upon the "biases against women in some natural sciences, especially those that involved field work" in the 1960s and 1970s. That participant expanded to share that "some professors actively discouraged most women from participating."

Other systemic barriers included white supremacy culture, which for some respondents did not cause a direct barrier, but did lead to "challenges being the only person of color" in a lab, field, meeting, or even an entire graduate program. This further supports results from studies of other disciplines in STEM and indicates a large-scale effort to remedy.

Finally, systemic issues such as the lack of opportunities available – both to learn about ocean science in grade school, and the competitive nature of the field as a whole – were represented in survey responses. One participant shared that "there aren't a lot of marine science opportunities presented within the public education system…a barrier for a lot of people who don't know where to look." And if individuals did know where to look, and still had a desire to pursue this field, the lack of jobs caused additional barriers. A survey respondent shared that they were "constantly stressed…how competitive marine biology can [be], especially if you want to stay in a particular geographic location."

A second category of barriers identified by survey respondents that supported previous research on barriers within STEM as a whole was financial barriers, specifically the lack of paid opportunities to grow and learn within the field. For example, ocean science camps and programs were "really expensive" and when there were no opportunities to learn about ocean science in classrooms, camps and extracurricular programs were one of the only options. Additionally, entry-level and early-career opportunities such as internships were "all unpaid and many charged for housing and participation fees. This made gaining off-campus experiences as an undergrad very challenging."

Leadership and mentorship, or the lack thereof, created additional barriers to the field of ocean science, similar to what is seen in STEM. Some respondents shared that they were first generation college students, and that there was "unfamiliarity in the household on how to look for opportunities and where to turn for resources." Other respondents shared examples where they lacked mentorship in their undergraduate years where they could have used additional help navigating networking, professional conferences, and the job search.

The final category of barriers that we noted were personal barriers. This category highlights some unique challenges that we have not seen mentioned in STEM literature. First, geographic location, as mentioned previously by the respondent regarding the competitive nature of jobs, was a limiting factor both in building knowledge and interest in the field, but also in finding job opportunities. For example, one participant shared that they grew up "in the Midwest [which] made it very difficult to pursue marine science efforts other than Great Lakes science." Geographic barriers were not the only personal barrier listed by survey respondents. Participants included psychological and physical barriers as well. The psychological barrier of finding a job

in a competitive market and "especially a decent-paying one" remains a stressor for many pursuing the field. Additionally, as previously noted that field work is a major component of many ocean science jobs, participants also shared that physical abilities can be barriers to careers. One participant shared that even when there is not a clinical disability, the "lack of strength and level of physical endurance [has] been a concern when it comes to the physical demands of fieldwork. I worry about avoiding injury and with keeping up with the physical demands of marine science fieldwork." These personal barriers demonstrate an extended list of barriers that represent the participants in the survey and may be more unique to some STEM fields such as ocean science.

DISCUSSION

Now that we better understand the flashbulb moments and significant life experiences that encourage individuals to pursue a career in ocean science, as well as the barriers that they may face along the way, what can we do with this data both from the perspective of marine educators and from the perspective of an ocean science institute?

REPEATED EXPOSURES LEAD TO CAREER PATHWAYS

One of our takeaways from this pilot study is the importance of repeated exposures to ocean science over the course of an individual's life, including informal learning and experiences in nature (Lucrezi et al. 2018). Many survey respondents shared a plethora of exposures to the field when asked for one flashbulb moment. For example, one participant explained that "a visit to the Baltimore Aquarium sparked an initial curiosity in the subject (I was about 11), which was multiplied when the BP oil spill in the Gulf occurred and I did a science fair project on cleaning [it up]." This highlights a specific case where the student needed that flashbulb moment to build an interest but then followed it up with another significant life experience. Another respondent shared that it

> started very young after a unit on marine science in first or second grade. However, it was really solidified when I visited my local aquarium after that unit and saw the marine mammal trainers working with the animals. That was the first memory I have of thinking 'wow, I want to do this'.

We argue that these repeated exposures are what encourage many, if not most, participants in pursuing a career. The curiosity is typically piqued by a flashbulb moment, and then there are a series of significant life experiences that continue to encourage and sustain that curiosity and interest over several years of development. Similar to research in STEM career development, multiple factors impact an individual's career choice, and formal and informal experiences play a large role (Ekmekci et al. 2019). Additionally, exposure at earlier ages would provide more opportunity for repeated experiences compounding into a sustained interest in the field. While our study found that over 60% of participants had meaningful ocean experiences within their K-12 career, other studies have suggested that the focus should remain on early elementary and early childhood experiences to set the groundwork for ocean literacy as early as possible (Tusan & Slown 2025).

We saw a shift in the themes represented between the flashbulb moments and the follow-up significant life experiences. In flashbulb moments, most of the participants shared events they participated in through structured and unstructured learning such as a camp, class, or visit to a museum or aquarium. This was similar to other studies noting access to informal learning as a positive impact on pursuit of an ocean science career (Windleharth et al. 2023). Then, we saw an increase in the reported significant life experiences toward personal connections (11%) and intrinsic value (36%), while the structured and unstructured learning maintained its influence for about 50% of respondents. This was similar to other studies that found "intrinsic passion" to be a large influence on the choice to pursue an ocean science career (Lucrezi et al. 2018, p. 398). We hypothesize that this shift is people seeking out more unstructured opportunities and building their general interest in ocean science (intrinsic value) as a result of that initial flashbulb moment. Therefore, in a sense, the SLEs are the repeated exposures, and those SLEs build both a continued passion for the field of ocean sciences and a desire to make a difference.

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BARRIERS TO OCEAN SCIENCE CAREER PATHWAYS

We expect that there are many additional barriers than were reported in this pilot study due to the lack of diversity within the research institution and participants' comfort with answering the question in full honesty. Despite this, participants did encounter barriers to the field of ocean science including systemic issues, personal barriers, and various discrepancies with levels of support. The types of barriers that were experienced varied based on the age of the respondent. Participants in the 21–39 year age group reported socioeconomic status as their more present barrier, while respondents over 50 years old listed gender identity as their largest barrier. Those in the middle (40–49 years old) shared that lack of support was their top barrier. While we expect that this data will shift given a national focus, it is interesting to see changes in barrier type across time. Despite some studies that state the consistency of gender and ethnicity barriers to the field (e.g., Windleharth et al. 2023), this data indicates that those new to the field are experiencing a different type of barrier related to socioeconomics. To address barriers that individuals face, certain barriers, such as those issues of white supremacy culture and gender discrimination require systemic focus both by individuals within the field and institutions of ocean science, such as institutes of higher education.

Personal barriers are more difficult to address, such as those living further from the coast. Although increased accessibility requirements for businesses and education organizations could improve limitations felt due to physical barriers. The category of barriers that is most accessible to change is through support to individuals who may be interested in pursuing a career in ocean science. As described earlier, this includes financial support to alleviate any limitations or burdens on the participant to experience ocean science courses, camps, and internships, but also includes mentorship and support from leaders in the field for all students and not just those that have privileges to connect more easily with the ocean science field. This focus is disproportionately important for communities underserved in ocean science, highlighting a need for K-12 education and outreach to reach all audiences. As the study found that 60% of respondents decided to pursue a career in ocean science by the time they graduated from high school, to capture the highest talent pool, focus should shift to younger students who have the opportunity for repeated exposures throughout K-12, undergraduate, and graduate careers.

The impetus for this study was the lack of long-term data related to individuals' pathways to ocean science careers. We suggest that having this information would benefit informal and formal ocean educators to recruit individuals into the field, as well as institutions of higher learning and ocean science research institutes to retain those who are interested until they can procure a position in the field.

RECRUITMENT INTO MARINE SCIENCE

From our perspective as informal educators, this information could be used for data-driven decision making within ocean science education and outreach programming to determine where our greatest effort should be placed. Currently, existing data can be restricted to satisfaction surveys or general interest in the field of ocean science (e.g., Erdoğan 2011; Schenkel 2002), but there is limited research on how specific programs impact career choices (Windleharth et al. 2023). For example, recipients of NOAA Graduate Research Fellowships are more likely to work within academic and research positions (Le & Bartolone 2015), but what life experiences led them to apply for that fellowship?

The pilot study results highlight several specific suggestions for informal education programming, related to curricula, timing, and funding. First, we suggest widespread integration of ocean science curricula into public school education, ensuring that all students – rather than only those with access to opportunities – are exposed to this field of study. The National Science Teachers Association (NSTA) and National Marine Educators Association (NMEA) recently released a joint position statement to this effect, suggesting that ocean education is critical to meet current and future challenges to the planet (NSTA 2025).

Secondly, the results suggest that the K-12 years are a critical time period for generating interest in the ocean sciences field. Despite this, limited opportunities to participate in ocean science activities restrict flashbulb moments which we have seen are critical and very commonplace for stimulating interest in ocean sciences as a potential career pathway. This supports inclusion both in the formal K-12 curriculum, but also informal education programming as a key pathway

to pursuing ocean science as a career. These informal experiences can "extend and deepen" (p. 11) students' learning within the field of ocean sciences, and could include opportunities such as camps (Roberts et al. 2018). Additionally, studies have shown that additional informal experiences can contribute to a sustained interest especially with underserved students such as those in urban and high-poverty communities (Basu & Barton 2007). Similar to Tusan & Slown (2025), we suggest informal educators review the levels of programming offered to varying age groups to assess possibilities to target younger audiences.

A final consideration from the study results highlighted the need for funding to support students with financial barriers to participate in programming such as camps and internships. This barrier extends between both the recruitment and retention of interest in the ocean sciences career pathway and is critical to recruit individuals into the field across diverse backgrounds.

RETENTION WITHIN MARINE SCIENCE

For research and higher education institutions, several key pieces of information came out of this pilot study. Again, financial assistance and paid opportunities are needed for supporting students at the undergraduate and graduate level. This is especially critical for those students who are first generation or are underrepresented in the field. But support for students also extends beyond financial assistance, with necessary support including advisors, networking and job search support, and assistance with applying to both undergraduate and graduate schools.

A second suggestion to retain students within ocean sciences is through mentorship. When students are involved in programs and opportunities where they interact with professionals and mentors who support their academic career, there is higher persistence towards graduation (Buschor et al., 2013; Packard & Nguyen 2003).

Finally, a secondary finding of this pilot study was the motivations for those already in the field to remain. Over 75% of participants cited a desire to make an impact on society as one of their greatest motivations. Other motivations receiving more than 50% agreement from participants include the work environment, the degree of independence, and their identity as a scientist. Because of this data, we suggest that marine science institutions, such as institutes of higher learning, support broader impacts, education, and outreach, both themselves and within their undergraduate and graduate students, to support pathways to ocean science careers, as well as providing greater support for their own enrolled students. This focus will also broaden their direct impact on society, encouraging them to remain in the field.

CONCLUSION

While the data and analysis from this pilot study represent a small sample of ocean science professionals, it does provide insight into trends regarding flashbulb moments and significant life experiences. In the pilot study, the demographics represented a less diverse population than the entire field, but barriers were still identified that suggest takeaways for both informal marine science educators as well as ocean science institutions of higher learning. The current study did not include retired ocean science professionals, or those that have left the field for other careers which may highlight additional barriers. The study also served a more academic focus, rather than highlighting ocean science careers from commercial, government, and nonprofit entities. A larger, national study is underway to capture additional perspectives that will provide more significant findings for the field. This national study will have higher representation of diverse fields and racial and gender diversity as well. In the future, we suggest follow up qualitative and mixed methods studies to better understand flashbulb moments, significant life experiences, and barriers within the individual's context.

That being said, several insights were generated from this pilot study including the need for ocean science exposure and curricula at earlier ages to both increase ocean literacy and to inspire the next generation of ocean scientists. Flashbulb moments and significant life experiences in the ocean science field are key to creating pathways and are even more impactful when combined through repeated exposures. Finally, barriers to the ocean science field do exist, specifically due to gender, race, and economic background, but we provide some suggestions for overcoming these barriers and the importance in doing so to broaden our field and community.

DATA ACCESSIBILITY STATEMENT

The participants in this study did not give written consent for their data to be shared publicly, so due to the sensitive nature of the research, supporting data is not available.

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COMPETING INTERESTS

The authors have no competing interests to declare.

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REFERENCES

Basu, S. J., & **Barton, A. C.** (2007). Developing a sustained interest in science among urban minority youth. *Journal of Research in Science Teaching,* 44(3), 466–489. https://doi.org/10.1002/tea.20143

Bevan, B., Barton, A. C., & **Garibay, C.** (2018). *Broadening perspectives on broadening participation in STEM.* Center for Advancement of Informal Science Education.

Bischoff, P. J., Castendyk, D., Gallagher, H., Schaumloffel, J., & **Labroo, S.** (2008). A science summer camp as an effective way to recruit high school students to major in the physical sciences and science education. *International Journal of Environmental & Science Education, 3*(3), 131–141.

Brown, R., & **Kulik, J.** (1977). Flashbulb memories. *Cognition, 5*, 73–99. https://doi.org/10.1016/0010-0277(77)90018-X

Bueno, E., Velasquez, S. M., Deil-Amen, R., & **Jones, C.** (2022). "That was the biggest help": The importance of familial support for science, technology, engineering, and math community college students. *Frontiers in Education*, 7. https://doi.org/10.3389/feduc.2022.768547

Buschor, C. B., Berweger, S., Frei, A. K., & **Kappler, C.** (2013). Majoring in STEM: What accounts for women's career decision making? A mixed methods study. *The Journal of Educational Research, 107*(3), 167–176. https://doi.org/10.1080/00220671.2013.788989

Cagle, N. L. (2018). Changes in experiences with nature through the lives of environmentally committed university faculty. *Environmental Education Research, 24*(6), 889–898. https://doi.org/10.1080/13504622.2017.1342116

Chawla, L. (1999). Life paths into effective environmental action. *The Journal of Environmental Education, 31*(1), 15–26. https://doi.org/10.1080/00958969909598628

Chawla, L. (2001). Significant life experiences revisited once again: Response to Vol. 5(4) 'Five critical commentaries on significant life experience research in environmental education'. *Environmental Education Research, 7*(4), 451–461. https://doi.org/10.1080/13504620120081313

Chawla, L. (2006). Research methods to investigate significant life experiences: review and recommendations. *Environmental Education Research, 12*(3–4), 359–374. https://doi.org/10.1080/13504620600942840

Chen, C., & **Tsai, C.** (2016). Marine environmental awareness among university students in Taiwan: A potential signal for sustainability of the oceans. *Environmental Education Research, 22*(7), 958–977. https://doi.org/10.1080/13504622.2015.1054266

Cheruvelil, K., Soranno, P., Weathers, K., Hanson, P., Goring, S., Filstrup, C., & **Read, E.** (2014). Creating and maintaining high-performing collaborative research teams: The importance of diversity and interpersonal skills. *Frontiers in Ecology and the Environment, 12*(1). https://doi.org/10.1890/130001

Cook, S. B., Muller-Parker, G., & **Cook, C. B.** (2022). The NSF Graduate Research Program: An analysis of awards in the ocean sciences by gender and career stage, 1996–2021. *Oceanography, 35*(2), 18–25. https://doi.org/10.5670/oceanog.2022.212

Ekmekci, A., Sahin, A., & **Waxman, H.** (2019). Factors affecting students' STEM choice and persistence: A synthesis of research and findings from the second year of a longitudinal high school STEM tracking

study. In A. Sahin & M. J. Mohr-Schroeder (Eds.), *STEM Education 2.0: Myths and truths what has K-12 STEM education taught us?* Brill Sense. https://doi.org/10.1163/9789004405400_015

Erdoğan, M. (2011). The effects of ecology-based summer nature education program on primary school students' environmental knowledge, environmental affect and responsible behavior. *Educational Sciences: Theory & Practice, 11*(4), 2233–2237.

Estrada, M., Burnett, M., Campbell, A. G., Campbell, P. B., Denetclaw, W. F., Gutierrez, C. G., Hurtado, S., John, G. H., Matsui, J., McGee, R., Okpodu, C. M., Robinson, T. J., Summers, M. F., Werner-Washburne, M., & **Zavala, M.** (2016). Improving underrepresented minority student persistence in STEM. *Life Sciences Education, 15*(3), 1–10. https://doi.org/10.1187/cbe.16-01-0038

Fleming, L. E., Maycock, B., White, M. P., & **Depledge, M. H.** (2019). Fostering human health through ocean sustainability in the 21st century. *People and Nature, 1(3)*, 276–283. https://doi.org/10.1002/pan3.10038

Glithero, L. D., Bridge, N., Hart, N., Mann-Lang, J., McPhie, R., Paul, K., Peebler, A., Wiener, C., Yen, C., Kelly, R., McRuer, J., Hodgins, D., & **Curtin, F.** (2024). *Ocean decade vision 2030 white papers – challenge 10: Restoring society's relationship with the ocean*. Paris, UNESCO-IOC.

Houston, R., Och, E., Khan, M. J., Cabaero, L., Bull, H., & **Asundi, S.** (2022). *Recognizing and overcoming barriers to participation in STEM.* https://aerospaceamerica.aiaa.org/departments/recognizing-and-overcoming-barriers-to-participation-in-stem/

Johri, S., Carnevale, M., Porter, L., Zivian, A., Kourantidou, M., Meyer, E., Seevers, J., & **Skubel, R. A.** (2021). Pathways to justice, equity, diversity, and inclusion in marine science and conservation. *Frontiers in Marine Science, 8*. https://doi.org/10.3389/fmars.2021.696180

Kier, M. W., Blanchard, M. R., Osborne, J. W., & **Albert, J. L.** (2013). The development of the STEM career interest survey (STEM-CIS). *Research in Science Education, 44*, 461–481. https://doi.org/10.1007/s11165-013-9389-3

Lambert, J. (2007). High school marine science and scientific literacy: The promise of an integrated science course. *International Journal of Science Education, 28*(6), 633–654. https://doi.org/10.1080/09500690500339795

Le, V., & **Bartolone, J.** (2015). *Employment and professional productivity of Graduate Research Fellowship Program Fellows (1994–2011)*. Research Highlights, NORC at the University of Chicago. https://www.norc.org/content/dam/norc-org/pdfs/GRFP%20NORC%20Research%20Brief%20for%20DTP_February%202015.pdf

Lewis, S. A., Holloway, A., & **Yarincik, K.** (2023). Assessing diversity in US ocean science institutions: Insights from fifteen years (2007–2021) of OSER data. *Oceanography, 36*(4), 10–20. https://doi.org/10.5670/oceanog.2024.134

Li, D., & **Chen, J.** (2015). Significant life experiences on the formation of environmental action among Chinese college students. *Environmental Education Research, 21*(4), 612–630. https://doi.org/10.1080/13504622.2014.927830

Lucrezi, S., Milanese, M., Danovaro, R., & **Cerrano, C.** (2018). 'Generation Nemo': Motivations, satisfaction and career goals of marine biology students. *Journal of Biological Education, 52*(4), 391–405. https://doi.org/10.1080/00219266.2017.1385509

Maltese, A. V., Melki, C. S., & **Wiebke, H. L.** (2014). The nature of experiences responsible for the generation and maintenance of interest in STEM. *Science Education, 98*(6), 937–962. https://doi.org/10.1002/sce.21132

MdBio Foundation. (2015). *2015 STEM education survey*. MdBio Foundation, Inc. and Science Advisory Board. https://www.learningundefeated.org/survey-stem-professionals-cite-real-world-experience-as-career-catalyst-for-students/

Mohr-Schroeder, M. J., Jackson, C., Miller, M., Walcott, B., Little D. L., Speler, L., Schooler, W., & **Schroeder, D. C.** (2014). Developing middle school students' interests in STEM via summer learning experiences: See blue STEM camp. *School Science and Mathematics, 114*(6), 291–301. https://doi.org/10.1111/ssm.12079

NASEM (National Academies of Sciences, Engineering, and Medicine). (2016). *Barriers and opportunities for 2-Year and 4-Year STEM degrees: Systemic change to support students' diverse pathways*. The National Academies Press.

Nash, K. L., van Putten, I., Alexander, K. A., Bettiol, S., Cvitanovic, C., Farmery, A., Flies, E. J., Ison, S., Kelly, R., Mackay, M., Murray, L., Norris, K., Robinson, L. M., Scott, J., Ward, D., & **Vince, J.** (2022). Oceans and society: Feedbacks between ocean and human health. *Rev Fish Biol Fisheries, 32*(1), 161–187. https://doi.org/10.1007/s11160-021-09669-5

National Science Teaching Association (NSTA). (2025). *NSTA and NMEA release joint position statement on ocean literacy*. https://www.nsta.org/press-release/nsta-and-nmea-release-joint-position-statement-ocean-literacy

NOAA (National Oceanic and Atmospheric Administration). (2024). *Ocean literacy: The essential principles and fundamental concepts of ocean sciences for learners of all ages*. https://cdn.oceanservice.noaa.gov/oceanserviceprod/education/literacy/ocean-literacy-english.pdf

Packard, B. W., & **Nguyen, D.** (2003). Science career-related possible selves of adolescent girls: A longitudinal study. *Journal of Career Development, 29*(4), 251–263. https://doi.org/10.1177/089484530302900403

Perdrial, J., Kincaid, D. W., Stewart, B., Seybold, E. C., Chorover, J., Walls, L., Blouin, M., Toolin, R., Chorover, J., & **Lewis, C.** (2023). Equity, diversity, and community as the basis for critical zone science and education. *Earth's Future, 11*(2). https://doi.or/10.1029/2022EF002812

Rivera, M. A. J., Ambrosino, C. M., Manning, M. M., Soon, S. L., Rii, Y. M., & **Gorospe, K. D.** (2022). Broadening participation through research experiences in marine science: An early-admit immersive college course provides experiential place-based scientific training for Hawai'i high school students. *Oceanography, 35*(2), 60–71. https://doi.org/10.5670/oceanog.2022.204

Rhodes-Ondi, S., & **Ghardiri, M.** (2019). Inspiring middle school young women to achieve STEM careers through a nature-based summer mentorship program. *Connected Science Learning April–June 2019, 1*(10). https://www.nsta.org/connected-science-learning/connected-science-learning-april-june-2019/inspiring-middle-school-young

Roberts, T., Jackson, C., Mohr-Schroeder, M. J., Bush, S. B., Maiorca, C., Cavalcanti, M., Schroeder, D. C., Delaney, A., Putnam, L., & **Cremeans, C.** (2018). Students' perceptions of STEM learning after participating in a summer informal learning experience. *International Journal of STEM Education, 5*(1), 1–14. https://doi.org/10.1186/s40594-018-0133-4

Sahin, A., Ekmekci, A., & **Waxman, H. C.** (2018). Collective effects of individual, behavioral, and contextual factors on high school students' future STEM career plans. *International Journal of Science and Math Education, 16*(Suppl 1), S69–S89. https://doi.org/10.1007/s10763-017-9847-x

Schenkel, L. A. (2002). Hands on and feet wet: Linking high-ability students to marine scientists. *The Journal of Secondary Gifted Education, 13*(4), 173–191. https://doi.org/10.4219/jsge-2002-380

Snively, G. (2018). Significant life experiences and long-term orientations to the seashore. In G. Snively & W. L. Williams (Eds.), *Knowing home: Braiding Indigenous science with western science* (Book 2, pp. 116–141). ePublishing Services.

Steffen, W., Persson, A., Deutsch, L., Zalasiewicz, J., Williams, M., Richardson, K., Crumley, C., Crutzen, P., Folke, C., Gordon, L., Molina, M., Ramanathan, V., Rockstrom, J., Scheffer, M., Schellnhuber, H. J., & **Svedin, U.** (2011). The Anthropocene: From global change to planetary stewardship. *Royal Swedish Academy of Sciences*, *40*, 739–761. https://doi.org/10.1007/s13280-011-0185-x

Stevenson, K. T., Peterson, M. N., Carrier, S. J., Strnad, R. L., Bondell, H. D., Kirby-Hathaway, T., & **Moore, S. E.** (2014). Role of significant life experiences in building environmental knowledge and behavior among middle school students. *Journal of Environmental Education, 45*(3), 163–177. https://doi.org/10.1080/00958964.2014.901935

Tanner, T. (1980). Significant life experiences: A new research area in environmental education. *The Journal of Environmental Education, 11*(4), 20–24. https://doi.org/10.1080/00958964.1980.9941386

Tusan, A., & **Slown, C.** (2025). Early and intentional marine science exposure fosters long-term interest in STEM fields: A preliminary study. *Current, 40*(3), 6–19. https://doi.org/10.5334/cjme.140

Windleharth, T. W., Holladay, L., & **Katagiri, C.** (2023). More than a hobby: Marine science career development through the lens of social cognitive career theory. *Current, 38*(1), 42–55. https://doi.org/10.5334/cjme.83

Yang, Y., Tian, T., Woodruff, T., Jones, B., & **Uzzi, B.** (2022). Gender-diverse teams produce more novel and higher-impact scientific ideas. *PNAS, 119*(36). https://doi.org/10.1073/pnas.2200841119

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