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## BIPOC voices in ocean sciences: A qualitative exploration of factors impacting career retention

Jasmin Graham<sup>a,b</sup> , Gina Hodsdon<sup>a</sup>, Aly Busse<sup>a</sup>  and Michael P. Crosby<sup>a</sup> 

<sup>a</sup>Marine Science Laboratory Alliance Center of Excellence, Mote Marine Laboratory and Aquarium, Sarasota, Florida, USA; <sup>b</sup>Minorities in Shark Sciences, Bradenton, Florida, USA

### ABSTRACT

The aim of this study was to understand the factors that impact the recruitment and retention of scientists that identify as Black, Indigenous or as People of Color (BIPOC). A total of 47 BIPOC participants who are currently working or have worked in the field of marine science were recruited using a non-probability snowball sampling method to participate in semi-structured interviews which were analyzed using Astin's Input-Environment-Output framework and Social Cognitive Career Theory. Several interventions which have been put in place to address the systemic issues that have led to the exclusion of certain groups including BIPOC-focused programs, research experiences and mentorship were identified as having positive impacts on the cognitive-personal outcomes of sense of belonging (feeling of acceptance within a group), science identity (the self-categorization of one's self as a 'science person') and self-efficacy (belief in one's ability to succeed). Several factors including discrimination, lack of allyship and negative research or mentorship experiences were identified as factors that greatly reduce these cognitive-personal outcomes. In addition, all three interviewees who left the field of marine science mentioned research experiences where they felt unsupported as a contributing factor to them leaving the field. This study serves to exemplify that systemic issues that have been observed in other STEM fields exist in the ocean science field as well. The study uses a novel framework to present and analyze trends in the experiences of BIPOC ocean scientists around the world.

### ARTICLE HISTORY

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### KEYWORDS

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Marine Science; SCCT;  
Astin's I-E-O; BIPOC

### Inclusion note

In an effort to adopt an asset-based language approach as well as include members of the Asian community in this study, the authors have opted to broaden the scope of this study from what the National Science Foundation defines as underrepresented minority. The National Science Foundation's definition fails to recognize the nuances between Asian American and Pacific Islander ethnic groups (Nguyen et al., 2022). It also does not account for the fact that although some communities within the broader Asian community are well represented in some STEM fields, this is not true for all communities within the Asian community nor is it true for all STEM fields. In fact, many Asian communities are not well represented in the field of ocean science and therefore have been included in this study. For these reasons, although this project is funded by the National Science Foundation, the authors have selected participants that identify as Black, Indigenous or People of Color (BIPOC) and that is the term that will be used throughout this manuscript.

### Introduction

Threats to marine ecosystems, sustainability, and associated loss of biological diversity from environmental issues such as bycatch, habitat loss, climate change, ocean acidification, overfishing and pollution continue despite increasing application of nature reserves and regulations (Arthington et al., 2016; Crain et al., 2009; Eichbaum et al., 1996; Maragos et al., 1996; Halpern et al., 2007; Panti et al., 2019). The need for innovative, science-based solutions is becoming increasingly clear. If there is a diversity of perspectives within the field of marine science, there is increased opportunity for growth and change which cannot be achieved if the traditional status quo continues to remain unchanged and immovable. Job opportunities in the field of marine Science, Technology, Engineering and Math (STEM) continue to grow, but the racial disparity in scientists entering the field remains an issue (Riegler-Crumb et al., 2019). This inequity stems from systemic issues built into the foundation of western science which is rooted in colonialism and principles of exclusion hidden behind a guise of supposed

**CONTACT** Jasmin Graham  [jgraham@mote.org](mailto:jgraham@mote.org)  Marine Science Laboratory Alliance Center of Excellence, Mote Marine Laboratory and Aquarium, 1600 Ken Thompson Pkwy, Sarasota, FL 34236, USA.

 Supplemental data for this article can be accessed here.

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meritocracy. The disparity in marine science leaders has contributed inequitable and oppressive regulations that impact marginalized communities (Barbour & Schlesinger, 2012; Dawson et al., 2018). For decades, Native Hawaiians were prevented from utilizing natural resources of Kaholawae Island until the U.S. Department of Defense returned the island to the State of Hawai'i in 1994 with the establishment of the Kaho'olawe Island Reserve Commission that was able to develop a plan to ecologically restore the island with emphasis on traditional Hawaiian methods of monitoring, managing, and protecting marine and coastal resources (Crosby et al., 2000; Weijerman et al., 2021). These issues related to social justice and inclusion in marine conservation may stem, in part, from a lack of representations within the marine science community. When decisions are being made, the impacts of the policies on BIPOC communities are often not fully considered because there is no one in leadership from those communities. In the US, approximately 35% of the population identify as Black, Latinx and/or Indigenous (U.S. Census Bureau, 2021). However, only 12% of marine STEM degrees are conferred to students from these groups (National Center of Education Statistics, U.S. Department of Education, 2017–2018). Despite recent efforts to promote diversity in marine STEM and the larger field of geoscience, the proportion of PhD-holding scientists in geoscience from these groups has remained stagnant (Bernard & Cooperdock, 2018).

Much work has been done to attempt to understand the factors that influence persistence in STEM careers among students who identify as Black, Indigenous or as People of Color (BIPOC) (Allen-Ramdial & Campbell, 2014; Estrada et al., 2016). It has been shown that there is a positive correlation between undergraduate research experiences (UREs) and enrollment in graduate degree programs (Carpi et al., 2017). The goal of UREs and other retention programs are to build self-efficacy, transmit knowledge, increase science identity, and provide mentorship, but not all UREs are created equal. Negative experiences or excessive challenges/barriers during UREs lowers students' self-confidence and damages the attitude a student has toward STEM (Carpi et al., 2017).

Recently, retention programs have focused on building self-efficacy (Ballen et al., 2017; Callahan et al., 2017; Chemers et al., 2011; Estrada et al., 2016; Herrera & Hurtado, 2011; Levine et al., 2007; Hurtado et al., 2009; Hurtado et al., 2010; Pender et al., 2010; Sasson, 2019). Self-efficacy, or the positive self-assessment of one's ability to succeed, can be built from mastery experience, vicarious learning, social persuasion, or physiological stimulation (Byars-Winston & Rogers, 2019). Retention programs provide targeted instructional interventions opportunities to participate in projects to build mastery experience. They are often structured to include a mentorship component as well to increase vicarious learning and social persuasion (Callahan et al., 2017). Increasing science identity is another major objective of most URE programs in recent years (Chang et al., 2011; Chemers

et al., 2011; Herrera & Hurtado, 2011; Hurtado et al., 2009; Hurtado et al., 2010; Sasson, 2019). Science identity can be developed within one's inner self but is often influenced by contexts like social and/or professional experiences (Callahan et al., 2017). However, science identity has many dimensions and can be invalidated as well as validated through these experiences (Stets et al., 2018). This is of particular concern when another prominent part of one's identity, for instance, one's racial identity, comes under attack in a professional STEM context. Cultural norms within STEM spaces are often characterized by white masculine values which can lead to identity interference among women and people of color whose other prominent identities might be treated as incongruent with these white masculine values (Byars-Winston & Rogers, 2019). This identity interference can contribute to feelings of alienation and may make potential mentors or faculty seem unapproachable. STEM spaces, including retention programs, may become hostile due to microaggressions in the form of microassaults, microinsults or microinvalidations (Lee et al., 2020; Miles et al., 2020; Wilkins-Yel et al., 2019). These factors, in addition to stereotype threat (Meador, 2018; McGee, 2018), could result in racial battle fatigue (Boone, 2018; Franklin et al., 2014) which can lead to further academic or social withdrawal, loss of focus or even premature departure from a program or major (Callahan et al., 2017). Feelings of alienation or prejudice are negatively correlated with BIPOC persistence and exposure to discrimination can severely disrupt BIPOC student's cognitive development (Chang et al., 2011). In fact, self-concept, or one's ability to deal with racism has been shown to be a better predictor of persistence in STEM than cognitive measures, indicating that the biggest challenges for BIPOC students in STEM are not academic (Chang et al., 2011). Research has shown that enrollment in Minority Serving Institutions (MSIs) or BIPOC-focused programs can serve as protective factors to mitigate the effects of racial discrimination (Callahan et al., 2017). Strong mentorship and having a supportive network of allies can also improve retention rates among BIPOC students (Chang et al., 2011). The aim of this study is to understand the role institutions, programs, mentors and experiences play in recruiting, supporting and retaining BIPOC marine scientists at various stages of their career.

This study will use Astin's I-E-O model (Astin & American Council on Education, 1991) as well as Social Cognitive Career Theory framework (Lent et al., 1994) to assess the variables and contexts that led to the persistence in or departure from marine science among 47 BIPOC scientists who currently or previously worked in the field of marine science. Unlike many studies (Ballen et al., 2017; Lee et al., 2020; Miles et al., 2020; Ovink & Veazey, 2011; Zhu et al., 2020) which focus only on the short to medium-term effects of one or two specific programs or interventions, this study will take a retrospective approach where interviewees will reflect on influential experiences they have had throughout their careers.

## Methods

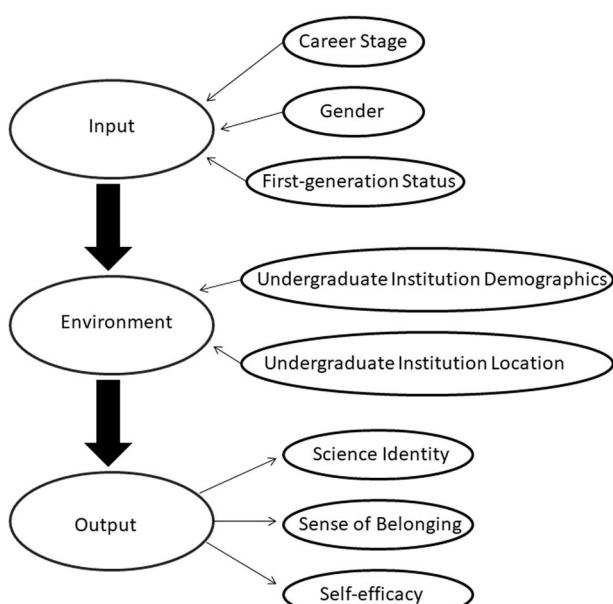
### Framework

The framework used in this study was derived from Astin's Input-Environment-Output model (Astin & American Council on Education, 1991) and Social Cognitive Career Theory (Figure 1; Lent et al., 1994). Astin's I-E-O model is typically used in analyses looking at a particular experience or intervention (Callahan et al., 2017; Sriram & Diaz, 2016). However, a broader approach was taken in this study to analyze participant's careers to a fuller extent versus a single point in time. Input is described as a participant's background and for the purposes of this study this included not only the racial, cultural, or socio-economic background of our participants, but also their K-12 experiences. While environment is typically defined by a single structured or semi-structured program, the interviewees entire career path from high school graduation to present in this study is considered. This includes factors such as undergraduate experience, graduate school experience, post-grad experiences, mentors, and professional networks as well as any specific or targeted programs or interventions they participated in. This novel definition of environment is applied due to the retrospective nature of this study and the fact that a person's experiences at various stages of their career can impact and influence their responses to environments in the future. Therefore while these programs can be thought of as individual environments as has been the case in the literature, they can also be additive and contribute to the larger environment in which one builds one's professional career. The final component of Astin's I-E-O model is outputs, which are the desired outcomes of a particular program or intervention. For this study, cognitive-personal factors are outputs considered as part of the Social Cognitive Career

Theory (SCCT) framework to analyze the components of career development including the internal factors associated with personal agency (the ability to direct one's actions toward a specific goal or purpose) as well as the external factors that can either inhibit or enhance personal agency (Lent et al., 1994). These include science identity, sense of belonging and self-efficacy. The combined framework of Astin's I-E-O and SCCT was used to identify what factors, strategies and interventions have proven successful (or unsuccessful) in increasing science identity, sense of belonging and self-efficacy.

Using the Astin's I-E-O model, the backgrounds of the interviewees was considered as an important *input* in their cognitive-personal outcomes. To get a better understanding of how differences in background affected self-reported outcomes, comparisons were made across career stage, gender and status as a first-generation college student. When thinking about one's academic and career *environment*, it is important to consider how the demographics of those around someone might impact their sense of belonging, science identity and self-efficacy (Byars-Winston & Rogers, 2019; Callahan et al., 2017; Chang et al., 2011). This is particularly true at the early stages of one's career (Medina, 2015; Riegle-Crumb et al., 2019). For that reason the demographics of participants' undergraduate institutions was considered an important factor in their environment. Due to the international nature of participants, a comparison between undergraduate environment of students in the US vs. outside of the US was included to address cultural differences between US institutions and non-US institutions as a factor of environment.

Astin's I-E-O model will provide the cognitive-personal and contextual factors needed for the Social Cognitive Career Theory framework. The SCCT framework will be used to understand how institutions, interventions, programs, and networks have 1) successfully or unsuccessfully recruited BIPOC marine scientists and 2) created environments that retained these BIPOC marine scientists. The factors influencing the cognitive-personal outcomes, particularly colleagues/peers and mentors, are present in a variety of contexts and some of these various contexts were analyzed to strengthen the social cognitive career theory framework used for this study. The combined I-E-O and SCCT framework will provide a general idea of what best practices should be initiated to recruit, support and retain BIPOC students in marine science.



**Figure 1.** Figure showing the framework used for this study which was a combination of Astin's Input-Environment-Output framework and Social Cognitive Career Theory.

### Data collection and analysis

A total of 47 BIPOC scientists who are currently working ( $n=44$ ) or have worked ( $n=3$ ) in the field of marine science self-selected to participate in this study (Table 1). A snowball sampling method using Twitter, word of mouth and calls to action within various BIPOC marine scientist groups was used to recruit participants. Semi-structured interviews (Supplementary material) lasting between 30 and 60 minutes were conducted and recorded via Zoom from May 27th, 2020 to August 12th, 2020. It is important to note that

**Table 1.** Table showing the demographic breakdown of the 47 participants.

<b>Career Stage</b>	
Grad Student	16
Early Career	18
Mid-Late Career	13
<b>Gender</b>	
Man	11
Woman	35
Non-binary	1
<b>First-generation Status</b>	
First-generation	17
Not First-generation	22
Unknown	8
<b>Undergraduate University Demographics</b>	
PWI	29
BIPOC	15
PWI with BIPOC program	3
<b>Undergraduate University Location</b>	
US	25
Not in the US	22
<b>Current Engagement in Marine STEM</b>	
Unengaged	3
Engaged	44

George Floyd was killed by police officers on May 25th, 2020 sending the US and much of the world into what could be described as a heightened sense of awareness of racial injustice. This sparked the Black in X movement on Twitter and led to the founding of several BIPOC-serving marine science organizations including Minorities in Shark Sciences, Latinx in Marine Science, BIPOC in Ocean Sciences and Black Women in Ecology, Evolution and Marine Science. In addition, this study was conducted during the global COVID-19 pandemic. While the data presented here is trustworthy as it comes straight from the mouth of the people who have lived these experiences, it is important to acknowledge that some of the events discussed in the interviews may have taken place several years before the interview which opens the door for potential recall bias. Given the context of the world at the time of the interviews participants were likely engaged in deeper reflection regarding their experiences and may even have been experiencing heightened emotions due to the traumas unfolding around the world.

Interview recordings were transcribed using NVIVO transcription software (QSR International Pty Ltd 2020) and automatic transcriptions were checked manually by the researchers. An open inductive coding scheme was used to identify codes, categories, and themes. Two researchers independently coded the same three randomly selected interviews. A coding scheme was developed from the codes with the highest percent agreement then the two researchers as well as a third researcher uninvolved in the building of the coding scheme independently coded three more randomly selected interviews using the established coding scheme to ensure validity and reliability in the coding method. Once 80%+ concordance in coding was established between all three researchers, the remaining interviews were divided between the three researchers to code independently. Interviews were qualitatively analyzed using a constant comparison method. The constant comparison method is an analytic approach which consists of comparing interpretations and findings against previous findings in order

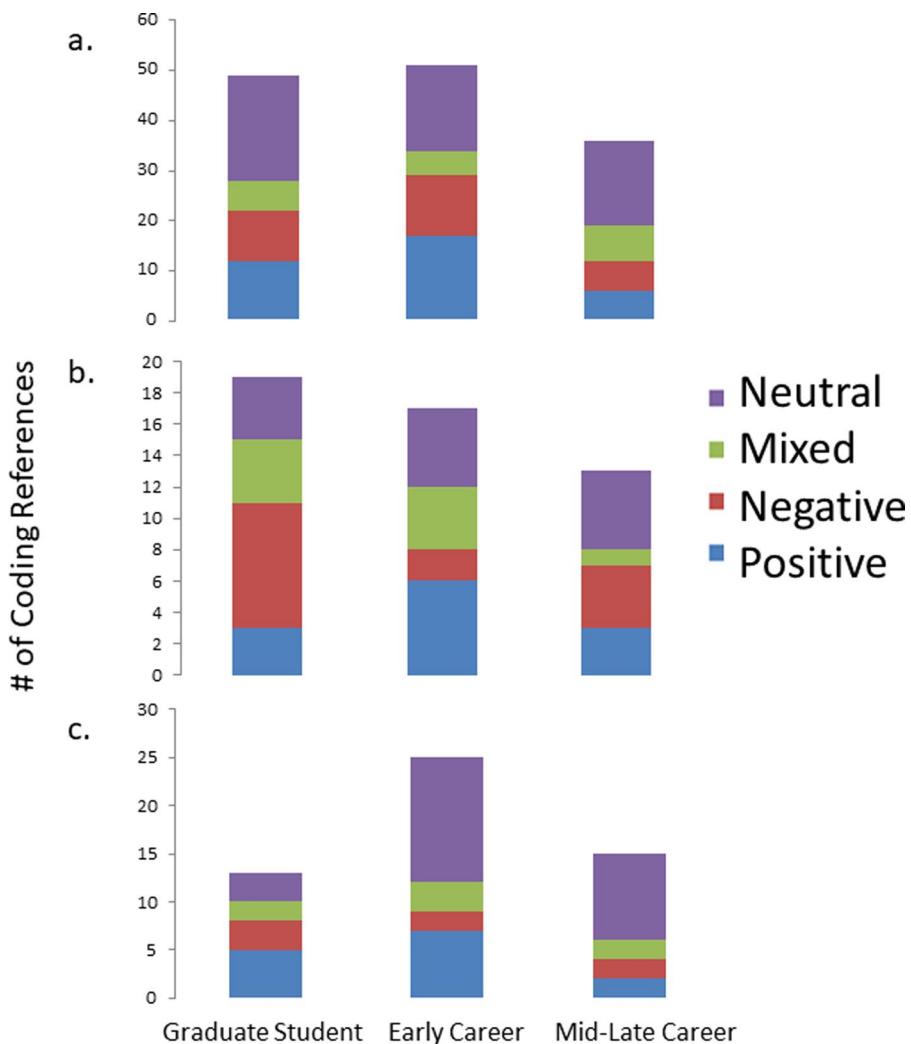
to categorize data into themes. Interviews were also autocoded for sentiment analysis using NVIVO (Hai-Jew, 2017). Sentiments were categorized as 1) positive if mostly positive adjectives and language was used, 2) negative if mostly negative adjectives and language was used, 3) neutral if mostly neutral adjectives and language was used or 4) mixed if an even mix of positive and negative adjectives and language was used. The results of this analysis were checked by a researcher to ensure no nuances were missed in the autocoding process.

## Results

### Astin's I-E-O

#### *Input: Career stage*

There were 16 participants who were graduate students, this included both master's and PhD students. There were 18 participants (15 currently in marine STEM and 3 not currently in marine STEM) who were in their early career, this included postdoctoral scholars and those within 5 years of completing their highest degree. Lastly, there were 13 participants who were in their mid to late career or were retired. The career stages of the 13 remaining participants were unknown and they were excluded from analysis. When comparing outcomes (Table 1) between the various career stages, graduate student, early career and mid-late career, sentiments toward sense of belonging moved from largely neutral among graduate students to fairly negative among mid-to late career participants. Sense of belonging (49 references among graduate students, 51 references among early career and 36 references among mid-late career participants) was an extremely prevalent factor and was mentioned more than self-efficacy (19 references among graduate students, 17 references among early career and 13 among mid-late career participants) and science identity (13 references among graduate students, 25 among early career participants and 15 among mid-late career participants) combined across all the interviews (Figure 2a-c). Sentiments toward sense of belonging varied for all career stages (Figure 2a). Sentiments toward self-efficacy are largely negative for graduate students while early career and mid-late career participants had more positive or neutral sentiments toward self-efficacy (Figure 2b). Self-efficacy was a more prevalent factor in the interview for graduate students (19 references) than it was for early career (17 references) and mid-late career (13 references) participants (Figure 2b). Sentiments toward science identity were mostly positive or neutral among early career participants. Graduate students also had largely positive sentiments toward science identity and mid-late career scientists were largely neutral. The theme of science identity, in general, was more prevalent in interviews with early career scientists (25 references) than in those with graduate students (13 references) and mid-late career (19 references) participants (Figure 2c).



**Figure 2.** Graph showing the number of references to and sentiments toward a) sense of belonging, b) self-efficacy, and c) science identity for the various career stages.

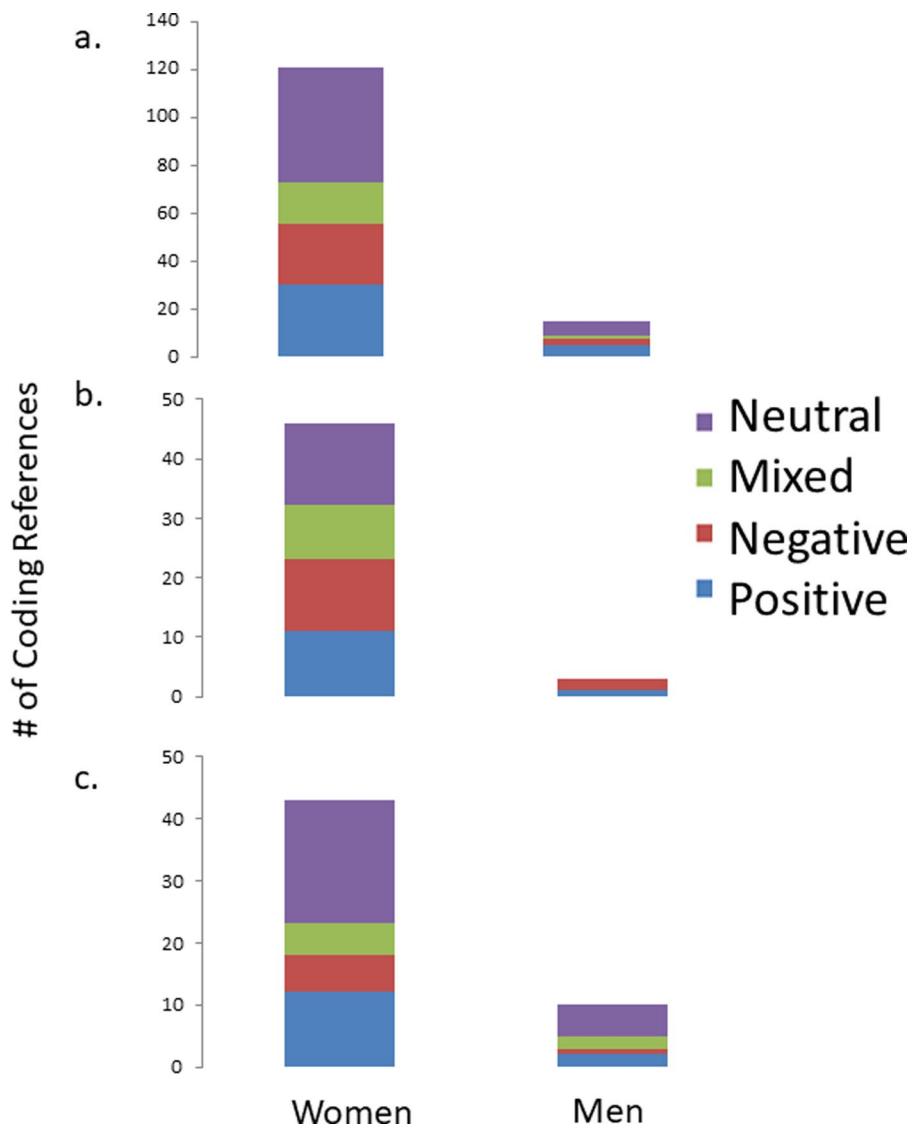
#### ***Input: Gender***

A total of 11 men, 35 women and one non-binary individual were interviewed. Sense of belonging was most prevalent in interviews with both men and women with participants having positive or neutral sentiments toward sense of belonging (Figure 3a). However, science identity was a more prevalent factor than self-efficacy for men (Figure 3b and c). In addition, sentiments toward science identity among women were slightly more positive than the men (Figure 3c). Men also had more negative sentiments toward their self-efficacy than women (Figure 3b). The non-binary individual only referenced a sense of belonging one time during the course of their interview and made no mention of self-efficacy or science identity. The most mentioned factors affecting the cognitive-personal outcomes for men were mentors, family/community, self-motivation, and financial considerations (Figure 4a). Men largely had positive sentiments toward their mentors, largely positive sentiments toward self-motivation and family/community, and negative or mixed sentiments toward their financial considerations (Figure 4a). The most mentioned factors affecting the outcomes for women were mentors, passion, family/community,

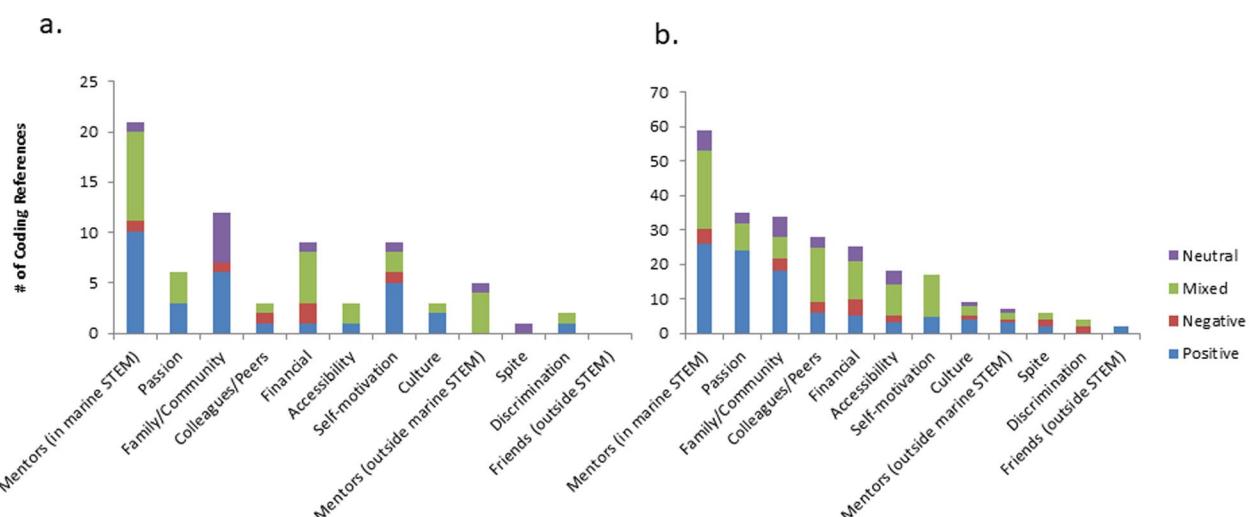
and colleagues/peers (Figure 4b). Sentiments toward family/community, passion and mentors were largely positive, while sentiments toward colleagues/peers were mixed among women (Figure 4b). The non-binary individual mentioned mentors and family/community as factors that contributed to their success. They had positive sentiments toward mentors, but their sentiments toward family/community were mixed.

#### ***Input: First-generation college students***

There were 17 participants who identified as first-generation college students and 22 participants who did not identify as first-generation college students. Eight participants were excluded from these analyses because their status as a first-generation college student was unclear. Sentiments toward all outcomes varied regardless of first-generation college student status with sense of belonging being the most prevalent outcome discussed (Figure 5a and b). Interestingly, science identity and self-efficacy were mentioned more in interviews with participants who were not first-generation, while sense of belonging was mentioned more in interviews



**Figure 3.** Graph showing the number of references to and sentiments toward a) sense of belonging, b) self-efficacy, and c) science identity for women and men.



**Figure 4.** Graph showing the number of references to and sentiments toward various factors of persistence for a) men and b) women.

with participants who were first generation college students. Despite the number of times these outcomes came up between the two groups, the distribution of sentiments was similar for both groups (Figure 5a-c). The most mentioned factors influencing the cognitive-personal outcomes for first-generation college students were mentors, financial considerations, family/community, and colleagues/peers (Figure 6a). Sentiments toward family/community were mostly positive and sentiments toward mentors, financial considerations, and colleagues/peers were mixed (Figure 6a). For non-first-generation college students the most mentioned factors were mentors, passion and financial considerations (Figure 6b). Sentiments toward mentors and financial consideration were also mixed for non-first-generation college students (Figure 6b). Sentiments toward passion were largely positive among non-first-generation college students (Figure 6b).

#### ***Environment: Undergraduate institution demographics***

Of the 47 participants, 29 attended universities that were predominantly (50% or greater) white, 15 attended universities with large populations (50% or greater) of BIPOC students and 3 attended universities that were predominantly white but had a BIPOC-targeted program within the larger university that the interviewee participated in. Participants who attended predominantly white undergraduate universities' sentiments toward sense of belonging varied as did sentiments toward science identity, but sentiments toward self-efficacy tended to be more negative or mixed (Figure 7a-c). For participants who attended universities with a large population of BIPOC students, sentiments toward sense of belonging and self-efficacy were varied while sentiments toward science identity were largely positive (Figure 7a and b). Participants who attended predominantly white undergraduate institutions but participated in BIPOC-targeted programs had slightly more positive sentiments toward sense of belonging in their interviews than those who attended predominantly white undergraduate institutions but did not participate in a BIPOC-targeted program (Figure 7a). Participants who attended predominantly white institutions with BIPOC-targeted programs had neutral sentiments toward self-efficacy while their sentiments toward science identity varied (Figure 7b and c).

The major factors influencing the cognitive-personal outcomes for participants who attended universities that were predominantly white were mentors, family/community, financial considerations, and passion (Figure 8a). Sentiments toward mentors were mostly positive or mixed and sentiments toward family/community were largely positive with some mixed sentiments. Sentiments toward financial considerations were largely mixed (Figure 8b). Family/community and passion were the major factors affecting outcomes among participants who went to universities with large populations of BIPOC students and sentiments were largely positive toward both of these factors (Figure 8b). For participants who participated in BIPOC-targeted programs within predominantly white

universities, family/community, colleagues/peers, mentors, and financial considerations had the most impact on their outcomes (Figure 8c). Their sentiments toward all of these factors were largely positive (Figure 8c). Another interesting finding is that participants who attended predominantly white undergraduate institutions but participated in a BIPOC-targeted program were more heavily influenced by colleagues and peers. This indicates that BIPOC-targeted programs are effective at building a sense of community within cohorts which has positive impacts on outcomes. In fact, among this group, mentorship is not as important of a factor, which suggests that strong peer support can be just as influential, if not more influential than mentorship.

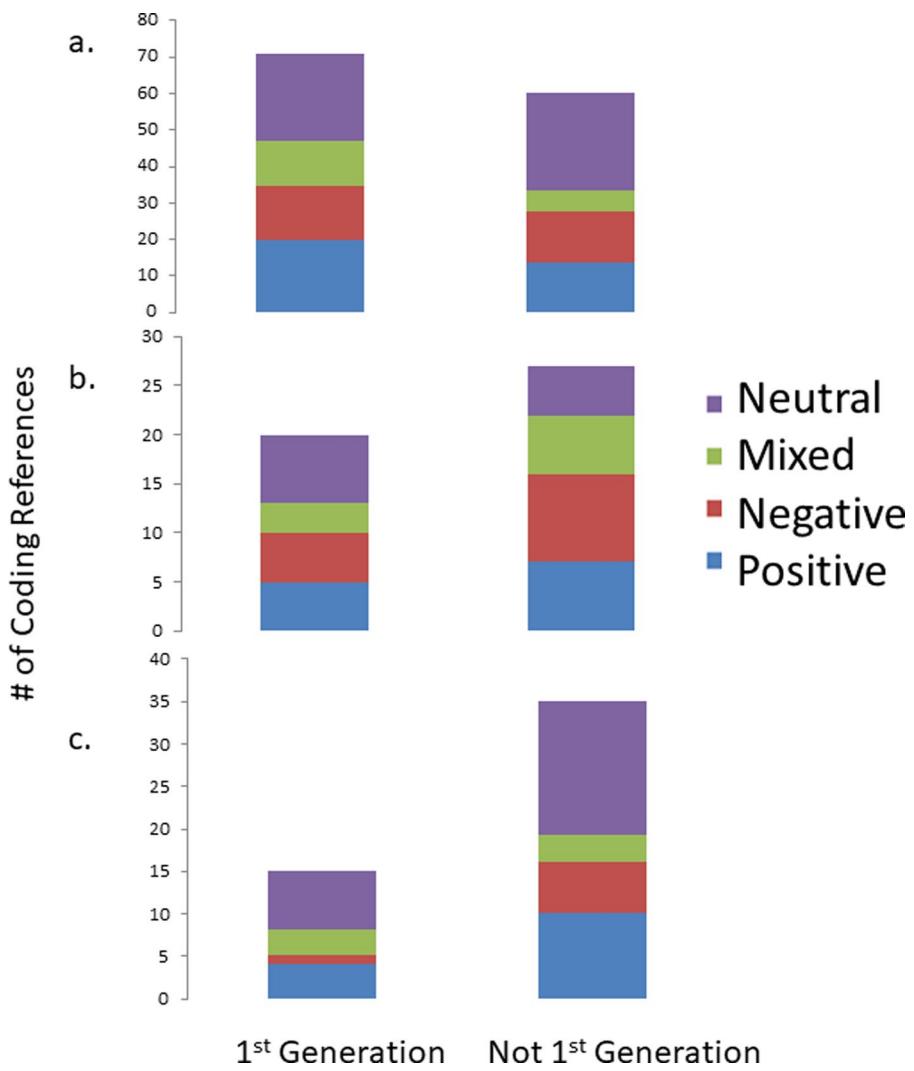
#### ***Environment: Location of undergraduate institution***

Although there were participants who completed their undergraduate education in various countries around the world (Figure 9), more than half of participants attended undergraduate programs in the US. There were 25 participants who attended undergraduate universities in the US and 22 participants who attended undergraduate universities outside of the US. Sentiments toward both self-efficacy and sense of belonging varied (Figure 10a and b). Sentiments toward science identity were largely positive or neutral for those who attended undergraduate institutions outside of the US and science identity was brought up in interviews more than self-efficacy for both groups of participants (Figure 10c). Mentors, family/community, and passion were all prevalent factors affecting cognitive-personal outcomes regardless of whether participants attended undergraduate within the US or outside of the US (Figure 11a and b). Sentiments toward mentors were mostly positive or mixed and sentiments toward family/community were largely positive across both groups (Figure 11a and b). For those who did undergraduate in the US, colleagues/peers were also a major factor and sentiments were largely mixed (Figure 11a). For those who did undergraduate outside of the US, financial considerations were a major factor with very few positive sentiments expressed (Figure 11b).

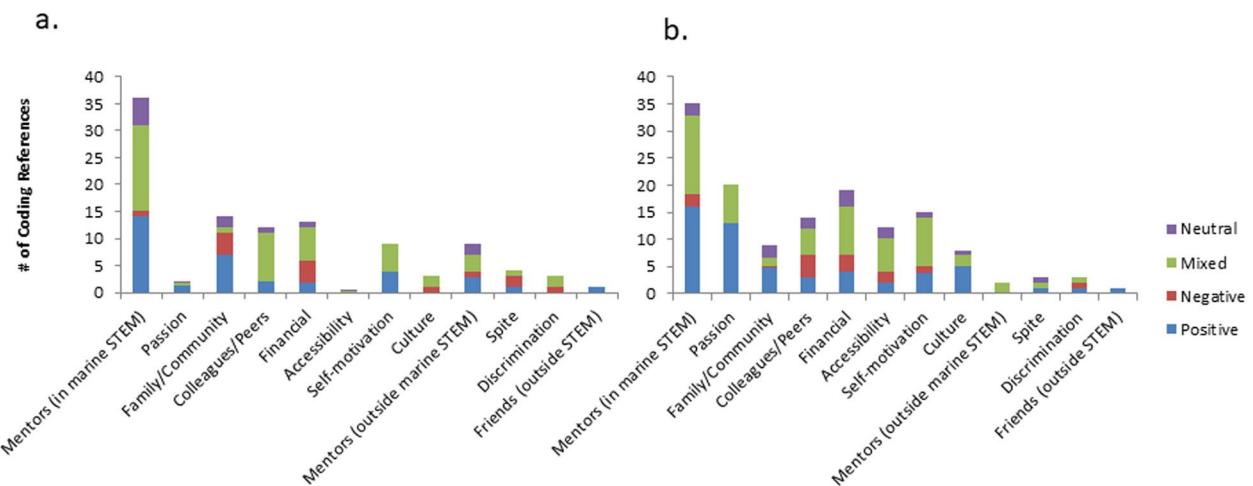
#### ***Social cognitive career theory***

##### ***Cognitive-personal outcomes***

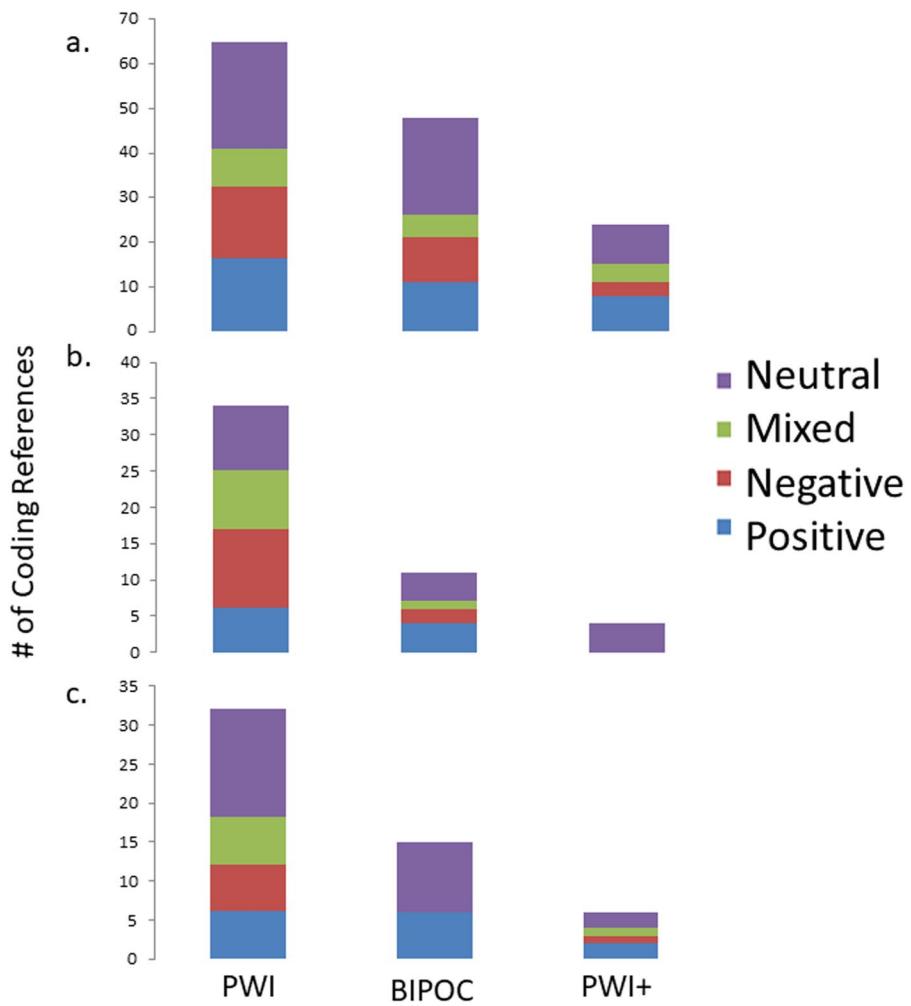
Sense of belonging, science identity and self-efficacy were the cognitive-personal outcomes that were evaluated using the Astin's I-E-O model. These outcomes were also evaluated using the SCCT framework to determine what factors/interventions play a role in positively or negatively impacting the cognitive-personal outcomes. Figure 12 shows the factors influencing the cognitive-personal outcomes along with the number of participants who mentioned them as a contributing factor. Mentorship, scientific societies/conferences and research/field experiences were mentioned by the most people as factors influencing their cognitive-personal outcomes. For most of the participants mentorship and research/



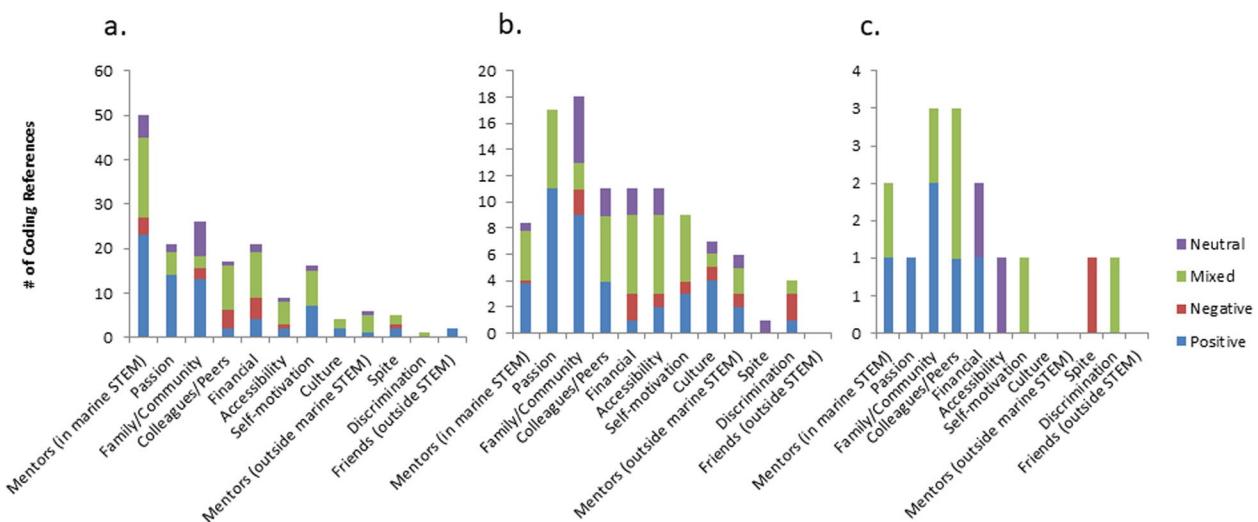
**Figure 5.** Graph showing the number of references to and sentiments toward a) sense of belonging, b) self-efficacy, and c) science identity for participants who identify as first-generation college students and those who do not identify as first-generation college students.



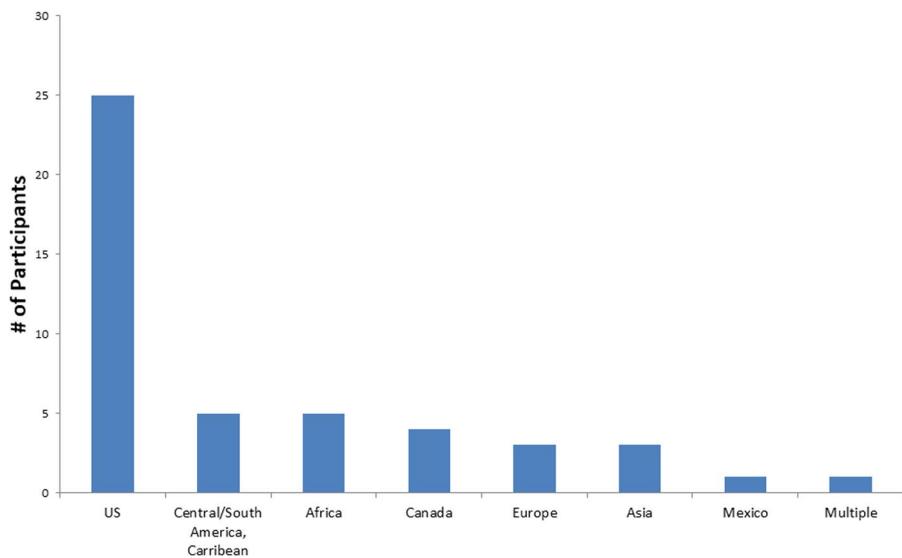
**Figure 6.** Graph showing the number of references to and sentiments toward various factors of persistence for participants who a) identify as first-generation college students and b) do not identify as first-generation college students.



**Figure 7.** Graph showing the number of references to and sentiments toward a) sense of belonging, b) self-efficacy and c) science identity for participants who attended predominantly white undergraduate institutions (PWI), predominantly BIPOC undergraduate institutions (BIPOC), and predominantly white undergraduate institutions that had a BIPOC-targeted program (PWI+).



**Figure 8.** Graph showing the number of references to and sentiments toward various factors of persistence for participants who attended undergraduate institutions that were a) predominantly white, b) predominantly BIPOC, or c) predominantly white with a BIPOC-targeted program.



**Figure 9.** Graph showing the breakdown of where each of the participants completed their undergraduate studies.

experiences had a positive impact on cognitive-personal outcomes. However, most participants cited scientific societies/conferences as having a negative impact. It is important to note that four participants mentioned shallow DEI efforts as having a negative impact on their cognitive-personal outcomes.

### Contextual factors

Colleagues/peers were occasionally associated with negative experiences such as ageism, sexism, and racism. However, colleagues/peers were also associated with the building of resistance capital among one participant. The importance of BIPOC peers was brought up by seven different participants. Mentorship was discussed in the context of a lack of mentorship by ten participants. Three participants discussed mentorship in the context of a negative experience. Three participants discussed their mentor acting as an ally and one participant attributed mentorship to building social capital. Mentors were mentioned by two participants in the context of formal research/field programs and fourteen participants discussed mentorship in the context of having BIPOC mentors.

### Persistence in marine STEM

Ultimately, Astin's I-E-O and social cognitive career theory frameworks are used to better understand how background and experience translate to persistence in marine STEM. Among our 47 participants, three have disengaged from marine STEM. However, each of these three participants are actively trying to get back into the marine STEM field but are having some difficulty. When comparing the sentiments toward each of the cognitive-personal outcomes, the largest difference is that sentiments toward science identity are more positive for those fully engaged in marine STEM than for those who are currently unengaged (Figure 13c). It is also important to note that, unlike their counterparts who

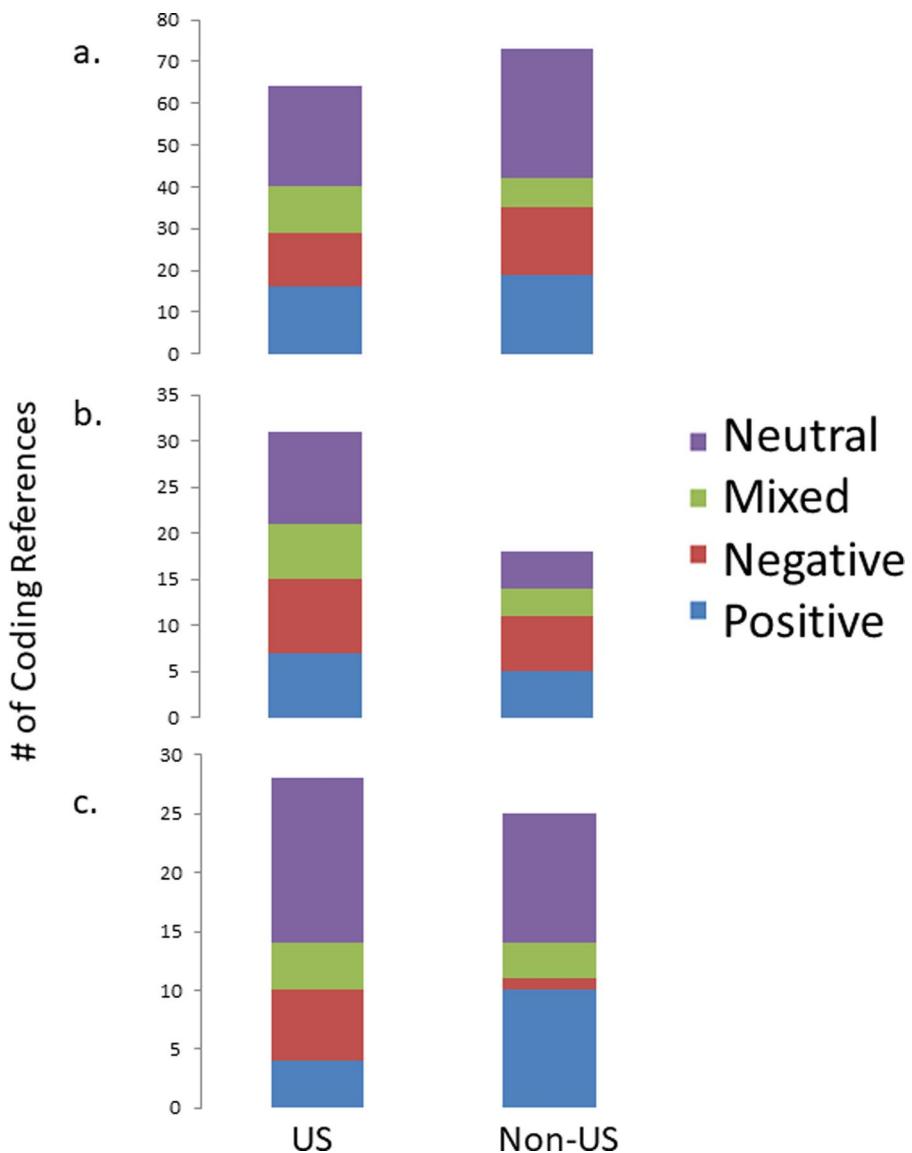
are currently working in ocean science, the participants that have left the field have no negative sentiments toward self-efficacy. The major factors impacting the cognitive-personal outcomes among participants who are currently unengaged in ocean science are family/community, mentors, accessibility, financial considerations, and colleagues/peers (Figure 14a). The only factor which has fairly positive sentiments is family/community (Figure 14a). The major factors impacting the outcomes among participants who are still fully engaged in STEM are mentors, family/community, passion, financial considerations, colleagues/peers, and self-motivation (Figure 14b). Sentiments are largely positive toward mentors, passion, self-motivation and family/community, but sentiments toward financial considerations and colleagues/peers are mixed (Figure 14b).

## Discussion

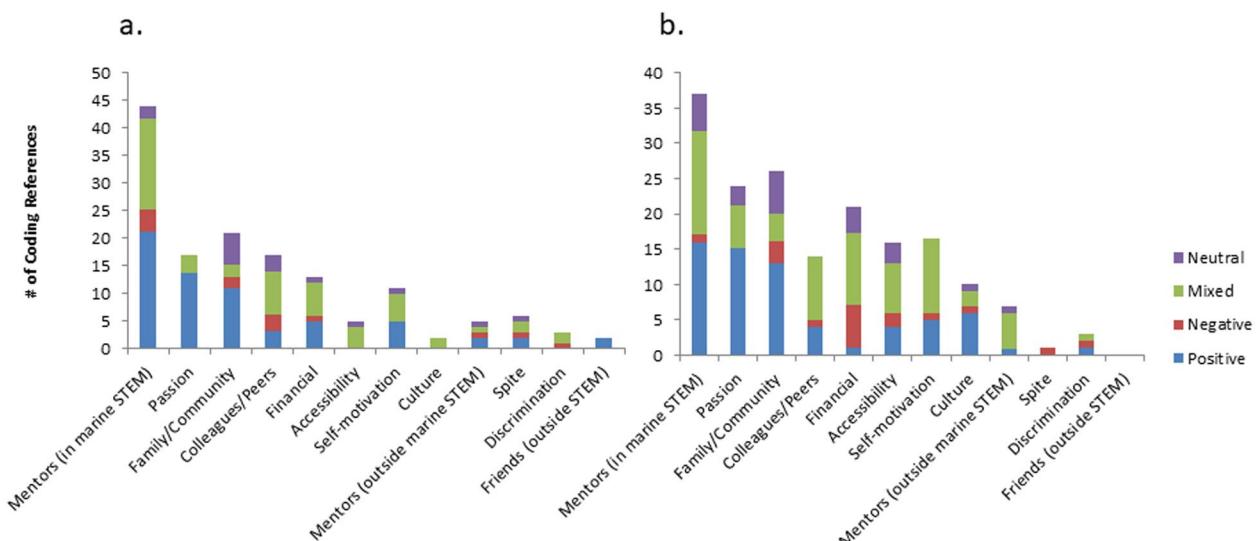
### Astin's I-E-O

#### *Input: Career stage*

The career stage of a participant at the time of the interview had a measurable impact on the way they described their career journeys, particularly as it related to our outcomes of interest, sense of belonging, self-efficacy, and science identity. Belonging is an important part of the human experience (Hagerty et al., 1992), so it is unsurprising that sense of belonging was the outcome that was most prevalent in participant interviews across all career stages (Figure 2). Low retention rates of BIPOC scientists in academic and research settings (Medina, 2015) are aligned with the results of this study that sentiments toward sense of belonging were less positive among mid-late career participants (Figure 2). The decrease in sense of belonging may be due to a build-up of microaggressions, negative experiences and other influences that may seem minimal alone but combine and accumulate as one progresses in their career. One participant describes it as, "Not super confrontational or in people's faces, but



**Figure 10.** Graph showing the number of references to and sentiments toward a) sense of belonging, b) self-efficacy, and c) science identity for participants who completed their undergraduate studies in the United States and outside of the United States.



**Figure 11.** Graph showing the number of references to and sentiments toward various factors of persistence for participants who attended undergraduate institutions that were a) in the United States or b) not in the United States.

kind of snide remarks or remarks, sexist remarks or kind of ethnic slurs." The interviews provide evidence that sense of belonging may be an extremely important factor in the retention of mid-late career BIPOC marine scientists.

The finding of Oswalt and Riddock (2007) that graduate students experience a significantly higher baseline stress level also aligns with the finding of this study that graduate students demonstrated a negative sentiment toward self-efficacy (Figure 2). Graduate programs can be extremely demanding and, in some cases, competitive environments which can lead to feelings of imposter syndrome and a lack of self-confidence (Bothello & Roulet, 2019). All these factors likely come into play for graduate students' self-efficacy. Once students finish graduate school and move into the workforce away from many of the stressors associated with graduate school, self-efficacy may improve. However, this study shows that early career and mid-late career participants still demonstrated mixed feelings toward self-efficacy. Although some of the stress associated with graduate school is lifted once scientists enter the workforce, this study indicates that for many BIPOC marine scientists self-efficacy is largely in flux (Figure 2).

Science identity was shown to be a more emphasized outcome in interviews with early career scientists (Figure 2) and is likely due to the strong need to establish oneself professionally at the beginning stages of one's career (Laudel & Gläser, 2008). Once scientists are feeling more secure in their career position after having worked in the field for several years, this need to establish a professional identity is lessened (Laudel & Gläser, 2008). On the other hand, graduate students who have not yet entered the workforce may not consider establishing a professional science identity as important because they are focused on gaining the skills to be successful once they enter the workforce making science identity a less important factor. Kajfez and McNair (2014) reported that graduate students often exhibit and must attempt to balance varying and sometimes conflicting professional identities. Early career participants, for whom establishing a strong science identity is critical, had largely positive sentiments toward science identity, while graduate student participants demonstrated more varied sentiments toward science identity (Figure 2). Sentiments were largely neutral toward science identity among mid-late career scientists (Figure 2).

#### ***Input: Gender***

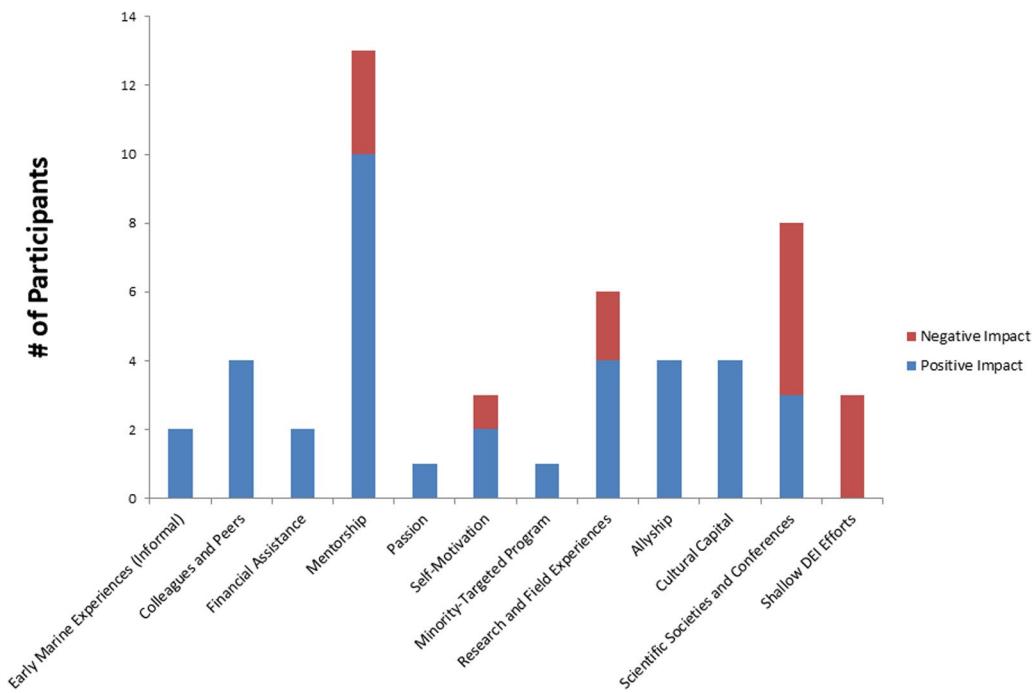
The skewed men to women ratio in interviews (23% to 74%) is comparable with the men to women ratio of students recently graduating with marine science degrees (<https://datausa.io/profile/cip/marine-biology-biological-oceanography>) and given that many (72%) of the participants in this study were students or had recently graduated, this is likely a representative sample. When comparing across genders, sense of belonging was also demonstrated to be the outcome that was most often discussed in interviews. Both men and women had varied sentiments toward sense of belonging, which indicates that gender is a less influential factor in one's sense of belonging. The

higher prevalence of themes relating to science identity among men may be a result of societal gender norms which often puts an emphasis on men being career-driven and ambitious, while it discourages those same qualities in women (Bowles et al., 2005; Brescoll & Uhlmann, 2005; Costrich et al., 1975; Glick & Fiske, 2001). Despite science identity being discussed less frequently among women, they felt more positive sentiments toward science identity as well as self-efficacy than the men. The reasons for this are currently unclear and further investigation is needed to better understand this phenomenon.

Mentorship was an important factor in positively influencing outcomes for both men and women, which is unsurprising given that mentorship has been shown in other studies to play a major role in retention of BIPOC students and positively impacting sense of belonging, science identity and self-efficacy (National Academies of Sciences et al., 2019). Men indicated self-motivation and financial considerations as important factors influencing their outcomes. This is likely tied to societal gender norms as well. Men are frequently expected to be very independent and self-sufficient while also being a major breadwinner and financial support system for their families (Riggs, 1997). Women were more heavily influenced by their support networks including family, community, colleagues, and peers. Women were also driven more by their own passions, likely because they feel less societal constraints regarding the expectation of financial stability (Riggs, 1997).

#### ***Input: First-generation college students***

While there weren't major differences in attitudes toward outcomes between first-generation and non-first-generation students, the prevalence of self-efficacy among interviews with first-generation college students indicates that self-efficacy might be a more influential outcome for first-generation college students. This is likely due to the lack of navigational capital that first-generation college students face (Beattie, 2018). Building self-efficacy may be even more important for first-generation college students because they don't come into college with the same tools, resources, and experiences as their colleagues. As is consistent across all inputs, mentorship was the most prevalent positive factor discussed. Family and community, while important factors for both first-generation and non-first-generation college students, had slightly different impacts between the two groups. As one participant explains it, "Not everyone...was thrilled about the idea of me becoming a scientist because it's not very... lucrative ...a lot of people said I could be using my intelligence for becoming a lawyer or a doctor or some[thing]." The disconnect that exists between first-generation college student participants and their families in the interviews was often linked to a lack of understanding of science, in some cases a complete distrust of science and a concern for their child taking an unknown path. It was interesting that non-first-generation college students mentioned financial considerations more than first-generation college students given that on average,



**Figure 12.** Graph showing the number of participants who mentioned various interventions as having either a negative or positive impact on the cognitive-personal outcomes.

first-generation college students come from lower economic backgrounds than their non-first-generation colleagues (Postsecondary Access and Success for First-Generation College Students). This could indicate that the increase of financial support for first-generation college students and students from low economic backgrounds may be effective in improving accessibility, but that these programs may need to be expanded to make the field more accessible for a broader range of students.

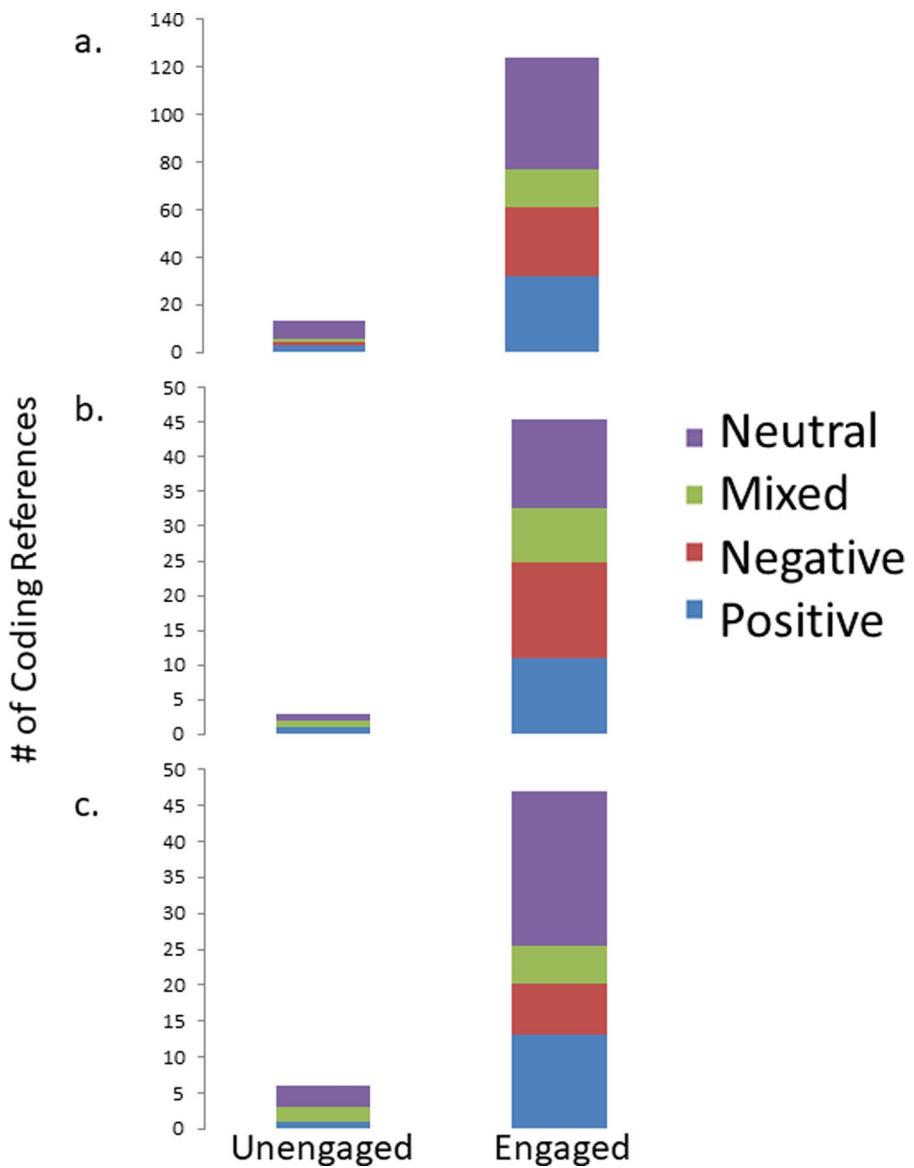
#### ***Environment: Undergraduate institution demographics***

The data from this study suggest that while institutions with large populations of BIPOC students appear to be more successful at building science identity in environments where students are somewhat insulated from discrimination and microaggressions, moving from these institutions can be a bit jarring for students as they move into the next stages of their careers affecting their overall sense of belonging. This study also provides evidence that students who attend predominantly white undergraduate institutions and participate in BIPOC-serving programs can maintain a stronger sense of belonging. Although institutions with more diverse demographics provide stronger science identity support, this study suggests that positive cognitive-personal outcomes can be replicated to some extent in BIPOC-serving programs within predominantly white institutions. Although many of the important factors influencing outcomes were the same for all participants, financial considerations were more important factors for those that attended predominantly white undergraduate universities, regardless of whether the participants were involved in a BIPOC-targeted program or not. This could

correlate with the fact that, on average, universities with large percentages of BIPOC students, especially Historically Black Colleges and Universities and Hispanic Serving Institutions, have lower tuition costs on average (McCarthy & Merisotis, 2005).

#### ***Environment: Location of undergraduate institution***

To acknowledge and contextualize the skew toward participants whose undergraduate institutions are in the US, participants who attended non-US institutions for their undergraduate degrees were grouped together to compare to participants who attended US institutions. There was little evidence of differences in cognitive-personal outcomes between those who attended US institutions for undergraduate and those who did not, with a few exceptions. First, participants who attended US institutions mentioned colleagues and peers as a factor effecting cognitive-personal outcomes than those who attended non-US institutions. This is likely due to the nature of how US institutions operate and the structure of the “college experience” at US institutions. Undergraduate institutions in the US often have a higher prevalence of students living in on-campus housing, extracurricular student activities and student-focused social events, while these things are less common in non-US institutions (Springer, 2020). Financial considerations were much more prevalent and had a more negative impact on outcomes for participants who attended non-US institutions. This is likely due to the disparity of funding and support for scientific research between the US and other countries (Wang et al., 2012), as noted by one participant from a non-US institution:



**Figure 13.** Graph showing the number of references to and sentiments toward a) sense of belonging, b) self-efficacy and c) science identity for participants who are still working in the ocean science field (Engaged) and those who are no longer working in the ocean science field (Unengaged).

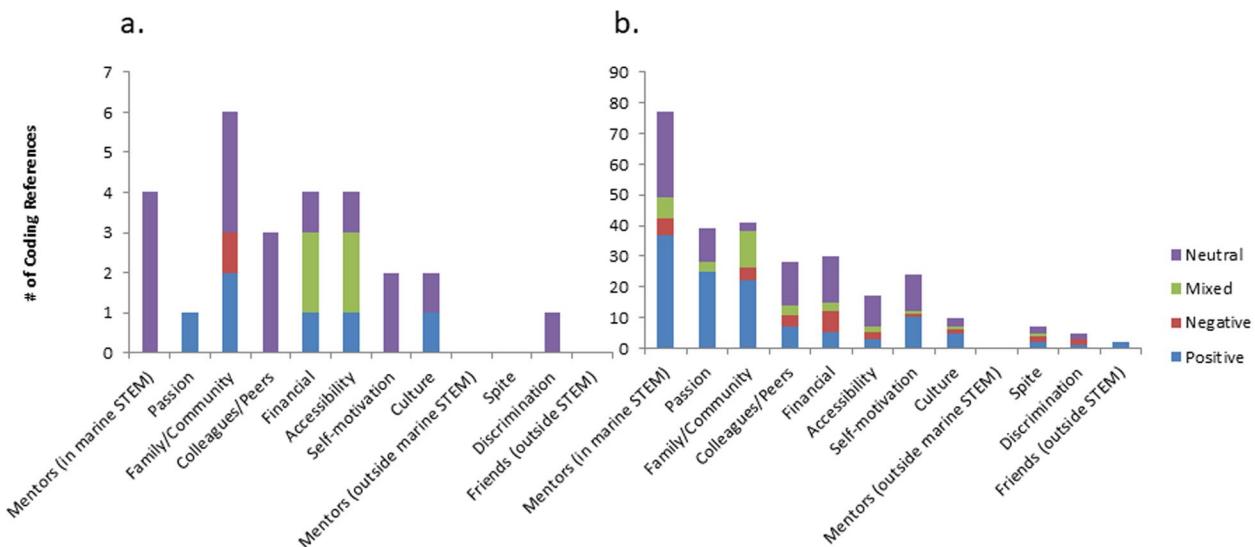
"I struggled a lot with, like research and samples that didn't really work. I did some research on genetics and I had a lot of trouble with that, underfunding. We had to pay for reagents and stuff out of our pockets. I think there is one big problem in this whole thing that we have to pay insane amounts of money to publish. And that is a very big problem. We don't really get paid in dollars, and so our currency right now is one dollar's worth four or five [of our currency] so it's like five times more expensive for us to publish in a leading journal, and we usually have to ask for a discount."

### Social cognitive career theory

As has been shown in previous studies, mentorship had a large impact on cognitive-personal outcomes (National Academies of Sciences et al., 2019) and these impacts were shown to be both positive and negative which demonstrates

the need for intentional and effective mentorship. In this study, mentorship was shown to have a major effect on two of the three outcomes, sense of belonging and science identity. Ill-equipped mentors have the potential to do irreparable damage to a mentee's cognitive-personal outcomes. While the study shows that a lack of mentorship has a severe negative impact on cognitive-personal outcomes, the data also show that having a bad mentorship experience can be detrimental to one's cognitive-personal outcomes and persistence in the field as well. One participant described a negative mentorship experience as a major factor that contributed to them leaving the field:

"I wrote a letter to some of my committee members about the fact that I am a product of their leaky pipeline, that they want to talk about fixing... Well, you lost a student and you all had control over whether or not that would happen. And here are the exact moments that you all dropped the ball. Step one, you didn't step in. You didn't



**Figure 14.** Graph showing the number of references to and sentiments toward various factors of persistence for participants who are a) no longer working in the ocean science field and b) currently working in the ocean science field.

step in with my PI when he's made some outlandish comments...two, you gaslighted me and told me that he really wasn't saying the things that he was. And, you all knew [this] was happening. And I couldn't imagine going through that again, like having that little support as a post doc."

The evidence suggests mentorship is key and it is therefore critical that mentors are provided with proper training and support. Colleagues and peers were also shown to be an important factor in influencing sense of belonging. However, discrimination, which was associated with both mentors and colleagues/peers, was mentioned as one of the main factors that shift mentors and colleagues/peers from having a positive impact on sense of belonging to having a negative impact. The data also suggest, however, that mentors can counteract some of the negative effects of discrimination through allyship. It is therefore important to include allyship training and/or cultural sensitivity training in any mentor training programs. One participant shared an experience where their Research Experience for Undergraduates (REU) mentor turned what could have been a negative incident, where a researcher falsely accused them of being 'unprofessional' into a positive experience through their support and allyship:

"I guess...being a person of color, you kind of get used to these kind of things happening. And so when it happens...most of the time you're not upset. You're just like, wow, another story to add to the list, right? But like at some point and this really sealed the REU as like one of my favorite experiences of my life. At some point, one of the two PIs found out about it, about the incident... and a couple of days later sent an email to everyone in the REU. And he [said] this is just some thoughts about... things I've heard. And it was a bunch of research... [about how] the way you speak doesn't really have any bearing on your intelligence or who you are as a person. And a bunch of stuff that was very clearly about the incident. And then he had like a little note

that said...I'm a middle-aged white man. I walk around in a Hawaiian shirt and cargo shorts, and nobody tells me anything about being improper or not looking like I should be doing research."

The building of professional networks, be it with mentors, colleagues, or peers, was often associated with conferences and academic societies. These spaces can have both positive and negative impacts on cognitive-personal outcomes in the same way mentorship can. It is therefore important to be intentional when creating these spaces. There were more participants that had negative experiences with conferences and academic societies than there were that had positive experiences. All the participants that reported positive experiences with conferences and academic societies mentioned participation in BIPOC-targeted programs within the society or conference structure. Similar to the importance of mentorship training, including allyship, cultural sensitivity or any other intentional diversity, equity and inclusion training for members of academic societies or conference attendees could go a long way in improving the experiences of BIPOC scientists in those settings.

Cultural capital was one of the major factors influencing science identity and sense of belonging. Cultural capital among participants came in the form of social capital (ability to secure resources through social connections), aspirational capital (ability to maintain hope for the future), linguistic capital (language resources), navigational capital (ability to navigate social institutions), and resistance capital (abilities fostered through opposition of inequity). Deficit-based models are often applied by researchers to understand lack of participation in STEM among BIPOC students (Zeidler, 2016), but the data suggest that BIPOC scientists are often tapping into their own cultural capital to build up positive cognitive-personal outcomes (Ovink & Veazey, 2011; Saw, 2020). Leveraging the cultural capital inherent in communities and families of scientists and

future scientists from BIPOC backgrounds may prove to be an effective strategy. Many participants mentioned being discouraged to tap into this cultural capital. As one participant shared, “It’s like that’s like number one in an indigenous culture is like you always introduce who you are, where you come from and what your purpose is for speaking at like a formal event. And it was just like, nope, you’re just a scientist. Just put all that away. So that’s very challenging.” However, by tapping into their own capital these scientists can not only mitigate the effects of identity interference but connect aspects of their identities to their science identity and extend their sense of belonging from their own communities into the scientific or academic community.

Lastly, research and field experiences were identified as a major factor impacting self-efficacy. This is unsurprising given the extensive research that shows the importance of research experiences in recruiting and retaining BIPOC students in STEM (Hintz et al., 2017; Zhu et al., 2020). As with other factors, this influence can be positive or negative, and the negative can be quite negative. In fact, one of the participants cited a bad research experience as the main reason they left the field of marine STEM, “I wanted to do a Masters. But I was like, you know what, I can’t I just have a bad feeling about going straight into grad school because I have such a bad experience doing my honor’s thesis...So kind of somehow transitioned and wiggled away from research because I had such a bad taste.”

Research experiences and field experiences must be developed intentionally to build positive cognitive-personal outcomes if they are to be effective at recruiting and retaining BIPOC students. Not all research experiences are created equal, and administrators should be cautious when building out these programs to ensure students feel supported, welcome, and set up for success. Every participant that left the field mentioned research experiences where they felt unsupported as a contributing factor to their exit and even participants that remained in the field described negative research experiences as low points on their career trajectory. Experiences must be intentionally designed, and administrators must ensure that mentors are willing and able to provide support, mentorship and allyship for all participants.

### **Limitations**

The largest limitation of this study lies in the sampling method. For one thing, because the snowball sampling relied on word-of-mouth it was difficult to find people who had left the field and so those voices are not as well represented. It’s also worth noting that because of our sampling method the majority of the participants had to be dialed in to some professional network either through social media, through associations or through BIPOC-focused organizations the authors reached out to for participants. Unfortunately, the people who likely are the most disconnected from others in the science field who likely bear the brunt of the barriers within the field would also likely not hear the call for participants. Another limitation lies in recall biases. For some

participants some of the stories and emotions shared were decades old and this might have affected the way they were shared. It is likely that details and emotions were missed or misremembered. It’s also important to note that with the passage of time emotions can be both dulled and heightened. Given the climate in which the interviews took place (at the height of a global pandemic and racial unrest) the feelings and emotions surrounding past traumas could have been heightened or participants may have been experiencing fatigue from having to confront these issues not only in the interview, but in their daily lives.

### ***Implications for ocean science***

The relatively small number of participants who left the field of marine STEM given the sample size of this study makes it difficult to draw too many generalizations, but the interviews with these participants still provide valuable information. For one thing, the fact that all participants not currently engaged in the marine STEM field are actively trying to reenter the field demonstrates that the issue is not in lack of interest or ability, but that there are barriers and challenges that discourage and, in some cases, prevent BIPOC scientists from continuing to engage in marine STEM. One participant described their challenges reentering the field:

“Now seeking the Marine research [jobs], I realized that the requirements again would be to outside of my scope, which I thought if [I completed a] Ph.D., I should be qualified enough... However, some of these ads for jobs that are put out there put requirements again for scuba diving licenses, or even ask for English proficiency tests, which is ridiculous because [I’m from] a country that is using English as its official language... when I couldn’t get any of those roles, I tried to do the internships. However, the internships and the field assistant type roles rarely have pay or if they do have pay, they have very little pay. And yet they’re a gateway to another role, because once you have that experience in field... what I realized [is that] because of the low pay, that means more and more people will come from communities that don’t have financial constraints... So that means the field is always going to remain tailor-made towards one group and excluding many other groups. I don’t want to have exited Marine research, I keep trying to rejoin. But the challenges are quite hard...I wouldn’t necessarily say it’s [my] training that lacks...I would say it’s the structuring of how the industry does its recruitment that ensures this criteria that sticks to [the] same culture and attitudes that marine science traditionally holds.”

This study shows that there are many barriers that BIPOC scientists face in pursuit of marine science careers and that, as evidenced by the three participants who left the field, there are BIPOC scientists with the desire to work in the marine STEM field that simply can’t overcome the obstacles placed in their path. The study also shows that while mentors, professional networks and research experiences can have positive effects on cognitive-personal outcomes and retention, when not done intentionally they can have the

opposite effect. On a global scale, the unequal distribution of scientific resources and capital translates to disparities in access when it comes to publications and grants. However, great work is being done using a variety of methods and it is important that journals and granting agencies recognize the value in work being done regardless of what technology is being used. It is equally important that the issue of pay walls and exorbitant publication fees is considered as a major barrier. Lastly, it is evident from these interviews that there are many systemic issues relating to discrimination and lack of representation that extend beyond the field of marine science directly that must be addressed in addition to the suggestions made here. The intricacies and intersections of one's personal and professional identity can make it difficult to manage a career in STEM in the face of threats to one's psychological and physical safety, as explained by one participant,

"I think it's something that people don't realize...I think it's something that is important for people to highlight is the fact that being a person of color and being Black, you have to deal with these issues at every single junction in your life, in every single compartment. It's not just one aspect that you have to deal with it's not just walking on the street, but every single point of my life I have to be thinking about this, whereas some other some people may not ever have to think about what this, what it feels like to be to have a spotlight on you."

A central theme of this study's results is that the field of marine science must start to address the systemic issues raised by participants in the study including the need for more inclusive scientific societies and conferences, impactful anti-discrimination policies and procedures, and, perhaps most importantly, increased access to strong mentors, research experiences, and BIPOC colleagues/peers. Faculty, staff, supervisors and administrators must focus on enhancing and supplementing the cultural capital of students and early career researchers and build environments that support and encourage them to bring their whole selves into the classroom, laboratory and field. By listening to the experiences and needs of BIPOC scientists, the field of marine science can begin to address the barriers and challenges that inhibit broader participation in the discipline.

### Future directions

A deeper exploration of the intersectionality between gender and race/ethnicity is needed to better understand how racism and sexism compound to impact the cognitive-personal outcomes of women of color. Similarly, this study did not look closely into other intersecting identities such as disability or sexuality, although these intersecting identities were brought up in several interviews. Additionally, for the purposes of this study BIPOC individuals were grouped together, but in doing so many nuances between different races, cultures and identities was lost. Further study exploring the experiences between different identities (including non-BIPOC scientists) would provide a fuller picture of the systemic issues facing BIPOC ocean scientists and provide

more context. Finally, because the field of ocean science doesn't exist in a vacuum, some next steps would include looking at how cultural and societal structures such as funding, housing, laws, regulations, political climate etc. impact the field of ocean science, particularly for BIPOC individuals.

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### ORCID

Jasmin Graham  <http://orcid.org/0000-0001-6838-6040>  
Aly Busse  <http://orcid.org/0000-0002-1466-5033>  
Michael P. Crosby  <http://orcid.org/0000-0001-6099-3305>

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