Breaking down barriers: The identification of actions to promote gender equality in interdisciplinary marine research institutions

Rebecca, J. Shellock.[1*], Christopher Cvitanovic.[1,2], Mary Mackay.[3,2], Merryn C McKinnon.[1], Jessica Blythe.[4], Rachel Kelly.[2,5], Ingrid E van Putten.[3,2], Paris Tuohy.[1], Megan Bailey.[6], Alpina Begossi.[7-9], Beatrice Crona.[10,11], Kafayat A Fakoya.[12], Beatrice P Ferreira.[13], Alice J.G. Ferrer.[14], Katia Frangoudes.[15], Judith Gobin.[16], Goh Hong Ching.[17], Paivi Haapasaari.[18,19], Britta Denise Hardesty.[3,2], Vreni Häussermann.[2O], Kelly Hoareau[21], Anna-Katharina Hornidge. [22], Moenieba Isaacs.[23], Marloes Kraan. [24,25], Yinji Li. [26], Min Liu.[27], Priscila F.M Lopes.[28], Marina Mlakar.[29], Tiffany Morrison.[30], Hazel A Oxenford. [31], Gretta T Pecl[32,2], Jerneja Penca.[33], Carol Robinson.[34], Samiya Selim.[35,36], Mette Skern-Mauritzen.[37], Kumi Soejima.[38], Doris Soto.[39], Ana K Spalding.[40-42], Alice Vadrot.[43], Natașa Vaidianu.[44,45], Mona Webber.[46], Mary S Wisz.[47].

[1] Australian National Centre for the Public Awareness of Science, Australian National University, Canberra, Australia.

[2] Centre for Marine Socioecology, University of Tasmania, Australia.

[3] CSIRO Oceans and Atmosphere, CSIRO, Hobart, Tasmania, 7001, Australia.

[4] Environmental Sustainability Research Centre, Brock University, St. Catharines, ON, Canada.

[5] Future Ocean and Coastal Infrastructures Consortium - Memorial University, Canada.

[6] Marine Affairs Program, Dalhousie University, Halifax, NS, Canada.

[7] NEPA (Núcleo de Estudos e Pesquisas em Alimentação), Universidade Estadual de Campinas, Av. Albert Einstein 291, Campinas, 13083-852, SP, Brazil.

[8] Fisheries and Food Institute – FIFO (www.fisheriesandfood.com), Rua Sousa Lima 16, Copacabana, 22081-010, Rio de Janeiro, RJ, Brazil.

[9] Graduate Group, Unisanta, 12 R. Cesário Mota 08, CEP: 11045-040, Santos, SP, Brazil.

[10] Stockholm Resilience Centre, Stockholm University, Stockholm, Sweden.

[11] Beijer Institute of Ecological Economics, The Royal Swedish Academy of Science, Stockholm, Sweden

[12] Lagos State University, Lagos, Nigeria.

[13] Universidade Federal de Pernambuco, Av. Professor Moraes Rego S/N, Recife, PE, 50670-420, Brazil.

[14] University of the Philippines Visayas, Miagao, Iloilo 5023, Philippines.

[15] University of Brest, Ifremer, CNRS, UMR 6308, AMURE, IUEM, Plouzané, France.

[16] Department of Life Sciences, University of the West Indies, St. Augustine, Trinidad and Tobago.

[17] Department of Urban and Regional Planning, Faculty of Built Environment, University of Malaya, Kuala Lumpur, Malaysia.

[18] Ecosystems and Environment Research Programme, Faculty of Biological and Environmental Sciences, University of Helsinki, Helsinki, Finland.

[19]Faculty of Law, University of Lapland, Rovaniemi, Finland.

[20] Pontificia Universidad Católica de Valparaíso, Facultad de Recursos Naturales, Escuela de Ciencias del Mar, Valparaiso, Chile.

[21] University of Seychelles *James Michel* Blue Economy Research Institute, University of Seychelles, Anse Royale, Seychelles.

[22] German Development Institute / Deutsches Institut für Entwicklungspolitik (DIE); and Institute of Political Sciences and Sociology, University of Bonn, Germany.

[23] Institute for Poverty, Land and Agrarian Studies (PLAAS), University of the Western Cape, South Africa.

[24] Wageningen Economic Research, Wageningen University and Research, Den Haag, Netherlands.

[25] Environmental Policy Group, Wageningen University and Research, Hollandseweg 1, 6706 KN, Wageningen, Netherlands.

[26] School of Marine Science and Technology, Tokai University, 3-20-1 Orido, Shimizu-Ku, Shizuoka, Japan.

[27] State Key Laboratory of Marine Environmental Science and College of Ocean and Earth Sciences, Xiamen University, Xiamen, China.

[28] Fishing Ecology, management and economics group, Department of Ecology, Universidade Federal do Rio Grande do Norte, Natal, RN, Brazil.

[29] Ruđer Bošković Institute, Division for Marine and Environmental Research, Bijenička 54, 10 000 Zagreb, Croatia.

[30] ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Queensland, Australia.

[31] Centre for Resource Management and Environmental Studies (CERMES), University of the West Indies, Cave Hill Campus, BB11000, Barbados.

[32] Institute for Marine and Antarctic Studies, University of Tasmania, Private Bag 49, Hobart, Tas. 7001, Australia.

[33] Euro-Mediterranean University (EMUNI), Kidričevo nabrežje 2, 6630 Piran, Slovenia.

[34] Centre for Ocean and Atmospheric Sciences, School of Environmental Sciences, University of East Anglia, Norwich, UK

[35] Social-Ecological Systems Analysis, Social Science Department, Leibniz Centre for Tropical Marine Research (ZMT), Bremen, Germany.

[36] Center for Sustainable Development, University of Liberal Arts (ULAB), Dhaka, Bangladesh.

[37] Institute of Marine Research, P.O. Box 1870 Nordnes, Bergen 5817, Norway.

[38] Faculty of Agriculture Department of Agri-Food Business, Setsunan University, Osaka, Japan.

[39] Interdisciplinary Center for Aquaculture Research (INCAR), Puerto Montt, Chile.

[40] School of Public Policy, Oregon State University, Corvallis, OR, United States

[41]Smithsonian Tropical Research Institute, Panama City, Panama

[42]Coiba Research Station (COIBA-AIP), Panama City, Panama

[43]University of Vienna, Department of Political Science, Kolingasse 14-16, Vienna, Austria.

[44] Faculty of Natural Sciences and Agricultural Sciences, Ovidius University of Constanta, Constanta, Romania.

[45] Interdisciplinary Center for Advanced Research on Territorial Dynamics, University of Bucharest, Romania.

[46] Centre for Marine Sciences, University of the West Indies, Kingston, Jamaica.

[47] World Maritime University, Malmo, Sweden.

* Lead Contact: Rebecca Jane Shellock

Telephone: +61 2 6125 0498

Email: rebecca.shellock@anu.edu.au.

Keywords: academia; diversity; equality; gender; intersectionality; STEM; leadership; marine science; equity

Summary

Interdisciplinary research is paramount to addressing ocean sustainability challenges in the 21st century. However, women leaders have been underrepresented in interdisciplinary marine research and there is little guidance on how to achieve the conditions that will lead to an increased proportion of women scientists in positions of leadership. Here, we conduct in-depth qualitative research to explore the main barriers and enablers to women's leadership, in an academic interdisciplinary marine research context. We found that interdisciplinarity can present unique and additional barriers to women leaders (e.g. complexity and lack of value attributed interdisciplinary research) and are

exacerbated by existing gender-specific issues women experience (e.g. isolation and underrepresentation and stereotyping). Together these barriers overlap forming the 'glass obstacle course'- and are particularly challenging for women in minoritized groups. Here, we provide a list of concrete, ambitious and actionable enablers that can promote and support women's leadership in academic interdisciplinary marine research.

Introduction

"We cannot all succeed when half of us are held back".

—Malala Yousafzai

It is increasingly acknowledged that a diversity of leaders, perspectives and disciplines are essential for navigating the complexity of environmental problems[1,2], including the socio-ecological challenges facing marine environments[3–6]. While it has become commonplace that marine research, like any other science, benefits from the inclusion of diverse scientific disciplines, the value of diversity in gender, ethnicity, nationality and other aspects (including disabilities) continues to be challenged [1,7]. The goal of gender equality has been reflected in the setting of global commitments[8] including the Sustainable Development Goals (SDGs) (e.g. SDG 5)[9] and the United Nations (UN) Decade of Ocean Science for Sustainable Developmnt (2021-2030)[10]. In the context of this study, gender equality refers to ensuring women have the same rights and responsibilities, are given the same opportunities and resources, and are not treated less favourably on the basis of their specific gender [11].For example, SDG 5.5 specifically aims to ensure that there are equal opportunities for women's leadership at all levels of decision-making in political, economic, and public life[12].

While the SDGs focus specifically on gender equality, there is also research which shows that women leaders encourage and drive innovation, creativity and scientific discovery[13], cultivate a more collaborative and inclusive research environment[14] and remove hierarchical power imbalances that have the potential to derail collaboration among researchers from different disciplines[15]. Throughout this manuscript, we use the terms "women" and "leader". We recognise that gender is not binary and we respectfully include and acknowledge the experiences and challenges of all who identify as women and/or womxn and also acknowledge that these and other challenges also exist for non-binary individuals[16]. For the purpose of this study, a 'leader' is defined as a researcher who holds some form of leadership role at any level within an academic institution (i.e. leading a research institution, team, project or program). Leadership roles are multifaceted and vary across regions and cultures, however, they often require leaders to assume a greater administrative and managerial load and service duties, in addition to their research role.

Despite the importance of diversity and inclusivity, gender inequity is pervasive across academic interdisciplinary marine research institutions [17–19]. In the context of this study, gender equity is defined as the practices and ways of thinking that assist in working towards equality, including ensuring women are given opportunities and resources that are proportional to their needs. Equity differs from equality in that it acknowledges that under-represented groups do not start from the same point, may face different systemic barriers, and therefore may require additional support to overcome these barriers" [11]. Interdisciplinary marine research integrates perspectives and approaches from the natural, physical and social sciences, which had previously been pursued independently, to create synthetic

understandings[20]. Research indicates that women are less likely than men to be in positions of leadership[21,22]. Following trends in other Science, Technology, Engineering and Mathematics (STEM) disciplines, previous studies suggest the proportion of women in leadership positions declines along the 'leaky pipeline', in the career trajectory from higher education to research[23–26]. Other studies have shown that despite similar proportions of women and men who enrol in undergraduate and graduate programs and acquire postdoctoral roles, leadership positions are predominantly held by men[27]. Earlier work has also shown that the leaky pipeline phenomenon can be further accompanied by gender inequity in terms of earnings[23,28,29], funding[22,30], awards[31] and publishing (e.g. authorship, number of citations, and leadership and membership of editorial boards [32–34]). Women often have shorter careers[35], receive more manuscript rejections[36–38] and are less likely to publish in prestigious journals[39]. While we acknowledge that each country, institution and discipline (whether natural or social science) will have its own specific context, studies suggest that women scientists from around the world are experiencing gender-specific biases that impede their advancement in research careers and attainment of leadership positions[40].

Pursuing gender equality in interdisciplinary marine research is critical. Gender equality is a fundamental human right and is essential for addressing sustainability challenges[41,42]. But, without understanding the gender-specific barriers that women face in relation to career advancement, it is impossible to ascertain how to navigate them[43]. There is a growing body of work which has enhanced understanding of the perceived gender-specific barriers and enablers to the advancement of women in STEM and related fields. Some of this research has gone so far as to suggest that the academic system has not been designed and developed to adequately support women scientists[38] or other minoritized groups[44,45]. As a result, women experience unconscious bias, cultural prejudices, stereotyping and expectations, as well as bullying and sexual harassment[46], which can inhibit career progression in STEM and put them at a significant disadvantage compared to their male colleagues[21,28,47–49]. This has previously been described as a 'labyrinth' or 'glass obstacle course'[50,51]. Together, these metaphors convey the various unequal and unseen gendered processes that are experienced by women scientists in the workplace and prevent women from rising to leadership positions within academia[50,52]. It is also important to note that the challenges experienced by women scientists are not experienced equally, but rather interact and accumulate with additional attributes including race[1], nationality [33], sexual identity, disability, age, culture and caring responsibilities[16,53,54].

Targeted actions are therefore needed to improve the conditions that will support an increased proportion of women scientists in positions of leadership. Research in STEM and related fields have put forward a range of potential enablers and strategies, including flexible working arrangements, institutional support, networking, support networks, mentoring, and role models[17,49,55–57]. To date, however, there has been limited research into the barriers and enablers experienced at the intersection between gender and interdisciplinarity, particularly within the context of marine research. This is

pertinent for a number of reasons. First, interdisciplinary research is paramount to addressing ocean sustainability challenges in the 21st century[58]. It is increasingly recognised that knowledge generation through single-discipline science is no longer adequate[15]; *'…biologists alone cannot solve the loss of biodiversity, nor chemists in isolation negotiate the transition to renewable energy"* [59]. Interdisciplinarity enables a more comprehensive understanding of problems, issues and complex phenomena, broadens the toolbox of methods and approaches used by scientists and actors, creates new knowledge on the multi-scale interactions between marine ecosystems and society and generates more robust and relevant outputs [60,61]. Second, recent evidence has shown that women leaders can increase the success of interdisciplinary marine research[15]. "*Women are well positioned to make major advances in interdisciplinary research, they may like to integrate across fields and approaches, work well in teams, and be committed to connecting their research with societal concerns"*[62] (p72). Thus, women's leadership will be significant to the future growth and success of interdisciplinary marine research. Third, the barriers to conducting interdisciplinary research are considerable, in comparison to single disciplines[63]. Interdisciplinarity can present unique and additional challenges to women scientists and may exacerbate the existing gender-specific issues experienced in marine research[64]. Barriers include: the lack of recognition of and discrimination against interdisciplinary research [65,66], disciplinary interaction (e.g. communication and power hierarchies between natural and social science), issues with integrating divergent disciplines in a meaningful way due to different epistemologies [67] and a lack of specific funding for interdisciplinary marine research [68]. Still, resources and human capital remain insufficient for overcoming current and future sustainability challenges[69]. It is counterproductive for sustainability, if women are being subtly and systematically excluded from leadership opportunities, whether intentionally or otherwise[70]. Interdisciplinary marine research environments must become more gender inclusive, empowering and appealing places for women scientists and potential leaders to work.

Here we aim to address knowledge gaps on the barriers and enablers of women's leadership in academic interdisciplinary marine research. The study has three main objectives: (i) to develop a comprehensive understanding of the main challenges and barriers of working in academia and undertaking interdisciplinary marine research, as perceived by women leaders; (ii) to develop a comprehensive understanding of the *gendered* challenges or barriers experienced by women leaders; and (iii) to identify enablers of women's leadership, including the promotion of and subsequent success of women's leadership (e.g. systems, processes and strategies). In-depth qualitative research was conducted using semi-structured interviews and self-completion surveys. 34 women leaders participated in the study, representing twenty-seven nationalities (see Table S1). The study was undertaken during the COVID-19 pandemic, a global event that brought to light many of the issues we see reflected in the responses[71,72]. We find that interdisciplinarity can present unique and additional challenges to women leaders working in academic marine research. Interdisciplinary

research is perceived to be undervalued and complex, and requires leaders to engage with a variety of disciplines, which can present challenges (e.g. due to differences in terminology, epistemologies and power relationships). These challenges are exacerbated by existing gender-specific issues that women experience (e.g. isolation and underrepresentation and stereotyping). These barriers intersect and overlap forming the 'glass obstacle course'- and are particularly challenging for women with multiple disadvantaged or minoritized statuses (e.g. ethnic minorities and leaders in the Global South). We propose a range of systems, processes and strategies which can promote and support women's leadership in academic interdisciplinary marine research. Social enablers (e.g. support and encouragement from supervisors and peers and informal networking) were the most frequently discussed, suggesting that support for women scientists may come from people, rather than training or institutional structures. By exploring the views of women leaders we can help to reframe the conversation around women's careers in academia, with important implications for academic interdisciplinary marine research institutions, the science community and more broadly, ocean sustainability. These insights can help to guide the design of gender equity initiatives, policies and frameworks which make steps towards gender equality in interdisciplinary marine research.

Results

Themes are presented as an analysis hierarchy. The analysis hierarchy provides an overview of the coding results and themes were ordered from those mentioned most frequently to those least frequently mentioned. However, it should be noted that frequency simply refers to the number of times each them was mentioned by participants, not the level of importance that participants placed on any specific issue. Specific themes, within each of the three research objectives, are detailed in the following subsection (see Table S2 for the overall sum totals for each theme).

Challenges of interdisciplinary marine research

Our first objective was to identify the main challenges for leaders working in academia and undertaking interdisciplinary marine research, from the perspective of women leaders. These are intended to be the non-gender specific barriers that participants mentioned they had experienced as leaders. However, there is a potential bias in the data, as we intentionally sampled women leaders. Additionally, we assume that the participants themselves selected themes related to this cluster of challenges, as opposed to the next cluster of challenges related to gender-specific challenges. Thus, it is impossible to confirm that these challenges are ungendered, but they are perceived to be ungendered. Most participants acknowledged that they had experienced challenges as a leader (N=30; 88.2%); four participants had not faced any general challenges as leaders (11.8%). The analysis identified 21 challenges. As described in the methods, they were categorised into the following themes: (i) institutional, (ii) practical and process, (iii) social, (iv) financial (v) individual, (vi) political and (vii) other (see Table 1). The ten most frequently discussed academic and

interdisciplinary challenges (or subthemes) are presented in Figure 1. Further information on each of the subthemes (with example quotes) are shown in Table S3.

Institutional challenges were the most common theme, highlighted by the majority of participants (see Table S2). Of these, the most commonly discussed institutional challenges were: (i) limited institutional support and capacity (N=15), (ii) academic or workplace culture (N=13) and (iii) institutional structure and policies (N=13; Table 1). Challenges identified under institutional support and capacity, included a lack of physical infrastructure to facilitate interdisciplinary marine research, as well as limited access to support and scientific staff. Participants discussed administrative overburden due to a lack of support within departments (e.g. for research management, teaching and financial management). This was seen to take leaders away from their research responsibilities and demotivated leaders. For example, one participant stated that *"Instead of having the time and creativity to spend on exercising leadership, I spend a lot of it on administrative duties. Most of these do not require my input, but we are a small team with lots of responsibilities"* (ID19).

The second most commonly discussed institutional barrier was that of academic or workplace culture. Participants discussed the competitive nature of academia, workload, the expectation to work long hours but also the presence of toxic and hostile working conditions (Table 1). For example, *"Things like when I was part time, that perception that you can't be a leader and serious about your work if you're part time"* (ID13). A third institutional barrier concerned institutional structure and policies (Table 1). Participants commented on issues including hierarchical structures, bureaucracy, and discrepancy between individual, team and institutional goals. For example, one participant commented, *"I find University/funding bureaucracy to be one of the biggest barriers in academia. I find being a strong and fair leader requires doing things that are right and just, doing things that are creative, and doing things that one may not have budgeted for at the outset. In all cases, these things (and understanding they are not mutually exclusive) tend to be difficult for rigid university systems to accept"* (ID33). Other institutional challenges included: (i) career progression and job insecurity (N=7), (ii) isolation and integration (N=6) and (iii) poor leadership within institutions (e.g. from superiors; N=4; Table 1).

In addition to institutional challenges, participants identified several practical and process barriers that influence interdisciplinary leadership (Table 1). Of these, the most commonly discussed subthemes were related to the challenges of being an interdisciplinary researcher. First, the lack of recognition and value attributed to interdisciplinary marine research was seen as a barrier (N=17). As exemplified by one participant: *"…I find my research misunderstood and I sometimes feel cut-off from disciplinary collaboration. I find that most of my invitations to collaborate in consortia is to do research on capacity building or societal outreach"* (ID10). The challenges of working with researchers from other disciplines was also commonly identified (N=13). One participant stated: *"…it is still very much compartmentalized – social and natural scientists do not mix or communicate with*

one another. In my work on marine social-ecological systems, this is quite the challenge – especially amongst natural scientists" (ID22). Closely associated with this, participants discussed the complexity of undertaking interdisciplinary marine research (N=13): *"It requires patience and stamina to lead processes to reach shared understanding and agreement of challenges, priorities and goals across disciplines, cultures, terminologies, that often differ from the discipline-specific priorities and goals"* (ID11). Other practical and process challenges related to: (i) leading and managing staff, (N=6) (ii) publishing (N=7) and (iii) the lack of leadership training (N=5; see Table 1).

By examining the challenges for leaders working within academia and undertaking interdisciplinary marine research, we were able to study biases and inequalities across different dimensions of human diversity and their intersections ('social challenges'; N=22, 64.7%). Social issues and multiple forms of discrimination combined and intersected the experiences faced by academics. One participant stated *"I think that age, place and race play important roles too, and that gender is only one aspect that may challenge leadership in marine interdisciplinary research"* (ID7). Multiple participants had experienced or observed discrimination and prejudice as a result of their race, ethnicity, or nationality (N=14). For example, *"[as] a woman of color, I especially feel that I need to do "extra" work or be "extra" good at what I do in order to be seen or heard as a reliable and valued voice"* (ID34). Participants discussed the implications of this discrimination, for example, in terms of isolation and exclusion from career progression: *"…it was just accepted there's no black woman, with a PhD, that can fill in positions"* (ID2). Participants were also discriminated against due to their age (N=12): "*…I won a big research grant and became both project Leader and Tenure Track Professor at my university. This time was hard, because colleagues subtly tried to question the fact that I deserve this grant. I was the first of the faculty that received it at a quite young age"* (ID7).

Another social challenge was inequality (N=8). For example, working in the Global South presented additional challenges for women academics (e.g. due to the lack of research capacity and funding, publishing, and progress in the field of interdisciplinary marine research). One participant commented: *"[It is] harder because of our 'developing country' status [a challenge] has been access to funding for research and student support. There is no national or even regional science fund to which we can apply annually, as is the norm for many developed countries"* (ID29). Finally, whilst mentioned less frequently, participants also outlined a range of financial, individual, political and other challenges (summarised in Table 1 and Table S3).

Gendered challenges experienced by women leaders

First, participants were asked whether they had experienced unique challenges, compared to males in the same position. Within our study, 24 out of our 34 (70.6%) participants perceived from their experiences that interdisciplinary marine research was more challenging for women leaders and they

would expect to spend more time on overcoming issues, compared to male colleagues. One participant stated: *"Marine and interdisciplinary research are traditionally considered as male dominant area thus having a female leading the project is assumed as 'less convincing'"* (ID18). Some perceived that it placed them in a double bind, due to gender stereotypes and negative perceptions of interdisciplinary marine research. This was exemplified by one participant who stated: *"I think a lot of single discipline senior men view interdisciplinary work as fluffy and not solid. So that's a definite barrier"* (ID13). This was in contrast to 7 participants who thought that it wasn't more challenging for women leaders (23.5%) and 2 participants who were unsure (5.9%). For example, some participants considered that interdisciplinary marine research may be more suited to women's skill sets or values (e.g. communication skills, multi-tasking and flexibility). One participant stated: *"I think women more easily see the value of interdisciplinary science. And they more clearly see that it is actually a particular skillset, working across the disciplines in an effective way is a particular skillset. And I don't think that is often recognised by, or it's less likely to be recognised by males"* (ID14).

Second, they were asked whether there were unique challenges for women scientists seeking to lead interdisciplinary marine research, compared to discipline-specific research. Within the study, 17 out of 32 (53.1%) thought that interdisciplinary marine research was more challenging than discipline-specific research for women leaders. Participants commented on the additional demands and mental load required for interdisciplinary marine research (e.g. gaining new skills and knowledge and engaging with a range of disciplines) which can negatively affect women leaders, who are time poor (e.g. due to domestic burden). One participant stated: *"[Women scientists] might be challenged with learning new research methods which require broad knowledge of different disciplines applied to marine research. Again, time - burden makes it challenging to seek sufficient time to seek new or advanced knowledge"* (ID23). This contrasted with 11 participants who did not think that interdisciplinary marine research was more challenging for women to lead, compared to discipline-specific research (34.4%) and 4 participants who were unsure (12.5%). For example, some participants thought that interdisciplinary marine research presented more opportunities for women compared to single-discipline research as: (i) it has greater (gender) diversity and representation, (ii) it is a newer, open and less competitive research area and (iii) it is more forward-looking and is more fluid compared to discipline-specific science. As exemplified by one participant, "…, *because the mono-disciplines have been developed for centuries and they are more competitive and for women it's more difficult also for cultural reasons. And interdisciplinary science is something newer and perhaps because it's a more open new niche there are more opportunities for women in this niche"* (ID31).

Third, participants were asked to reflect on the gendered challenges they faced as a woman leader in interdisciplinary marine research. Over 60% of participants perceived that they had faced gendered

challenges and identified the types of barriers and challenges (21/34; 61.8%). However, just under 40% of participants stated that they had not faced any specific gender-based challenges or were unable to identify them (N=13; 38.2%). In total, 23 specific barriers were identified and categorised into the following themes: (i) social, (ii) practical and process, (iii) individual, (iv) institutional, (v) financial and (vi) other (see Table 2 and Figure 1). The ten most frequently discussed gendered challenges (or subthemes) are presented in Figure 1. Further information on each of the subthemes (with example quotes) are shown in Table S4.

Social barriers were the most commonly discussed gendered challenge by participants (see Table S2). This theme was further described by six subthemes (see Table 2). Of these, the most frequently mentioned social challenges were: (i) isolation and underrepresentation (N=24), (ii) stereotyping (N=19), and (iii) expectations of women (N=19). First, participants commented on the feeling of isolation as a woman leader in academia, due to the male dominated environment and lack of women role models. One participant stated *"…the men who have these positions, it's not like they're male chauvinists, not at all, but how did we end up in this situation where all the professors are male? It's got to be something that is not an accident"* (ID5). Second, over half of participants considered stereotyping to be an issue in academia. Participants highlighted various gendered stereotypes that they had observed within academia and there was some variation across disciplines, countries, and cultural contexts. This included women academics being considered as: (i) less able leaders (ii) having an inferior performance on quantitative or mathematics-related tasks, (iii) being weaker and less able to take on physical tasks (e.g. during fieldwork), (iv) having caring characteristics (e.g. compared to men who are associated with confidence, dominance and self-reliance) and (v) being mothers or carers rather than scientists and leaders. Experience of this stereotyping was exemplified by one participant who referred to *"…the ancient setting with women taking care of children and home, and men as being busy businessmen or hunters, whatever, is also shown in the academy"* (ID8).

Third, expectations of women research leaders were also seen as a social challenge; these are the internally and externally applied beliefs of how women leaders should behave and the standards they should meet. Many participants perceived that there are double standards when comparing men and women working in academia. As illustrated by one participant: *"I think the expectations for women by women and men, like by everyone, are higher...if a woman does something wrong or whatever it's like well they should know better, men get away with it because they're men, but women should know better"* (ID13). Furthermore, participants discussed the perception that women are expected to work harder than male colleagues to be successful and are subject to greater judgement (e.g. their work and behaviour): *"…females have to work harder to get the results and the buy-in"* (ID27). Although mentioned less frequently, other social challenges related to: (i) engagement in external activities (e.g. experiencing stereotyping and sexualised behaviours when undertaking fieldwork, cruises and stakeholder engagement; N=12), (ii) power imbalance (i.e. the unequal distribution of control and

power held by men and women; N=8) and (iii) a lack of awareness of gender-issues in wider society (N=5; see Table 2).

In addition to the social challenges outlined above, participants also discussed several practical and process challenges (see Table 2). Most participants mentioned that parenthood and caring responsibilities were a barrier to women's leadership (N=27). Some highlighted that women leaders often had to make a decision and trade-off between work and having children, which was not perceived to be the same for the majority of men. Of those that had decided to have children, they continued to face trade-offs and barriers after they had given birth, particularly during the COVID-19 pandemic. As one participant stated: *"…many female colleagues suffer from being both a leader and top researcher and a mother. This has been especially an issue during COVID-19"* (ID7). Women scientists experienced isolation and the challenge of balancing work and home life, which had career implications (e.g. being unable to attend conferences, meetings and fieldwork trips, as well as having negative effects on their career trajectory). One participant described how they *"… have a huge responsibility as a mother, wife and care-taker of the family. These expectations weigh heavily on me and imposed limitations on my capabilities to excel in academia"* (ID23).

Participants also highlighted the often unseen and unsanctioned barriers which prevented women academics securing leadership positions (N=14). This is commonly known as the 'glass ceiling': *"…the glass ceiling that is often talked about is very much there and it comes in extremely cyclic forms and it's most powerful if one doesn't talk about it openly*" (ID9). Participants discussed the lack of equitable access to leadership positions for women scientists and situations where they themselves or colleagues had been blocked, delayed or held back from promotions and career opportunities (e.g. due to gender stereotypes and external responsibilities, such as parenthood). For example*, "…there is prejudice in the university work environment: women take longer to be promoted and must publish more than men for the same promotion"* (ID28). This was in addition to challenges such as job uncertainty or insecurity (e.g. due to short term contracts and having to move for work; N=5) and the gender pay gap (i.e. men having higher salaries; N=4).

Participants also identified several individual (i.e. personal) challenges facing women leaders. Over 60% of participants perceived that gaining credibility was a barrier for women scientists, as many had an expectation of different or diminished interests or abilities, due to their gender (N=22); exemplified in the following: "…*there are some things that don't come to us for granted, you don't get it straight away, you have to roll twice as much so there's that barrier in terms of prompt recognition, so we don't get recognition as fast"* (ID29). In addition, they had been given different tasks to men: *"There's still an expectation that in a meeting of senior scientists, any women present are the best people to take the minutes"* (ID6).

Bullying was also identified as an individual challenge (N=14). Participants recalled subtle workplace discrimination, particularly from senior colleagues, and observed belittling, misogynistic unprofessional remarks, and incidences of microaggressions. For example, *"I was told that I would never make it to full professor because everyone knows female professors are ruining the University…[also] men have challenged the way I have said something i.e. the pitch of my voice*" (ID17). Microaggressions included 'mansplaining' which describes an explanation, usually offered by a man, which is patronizing, condescending, or ignores women's experience and knowledge[73]. Another type is 'hepeating' which occurs when a male colleague appropriates comments or ideas that were originally highlighted by a woman and is praised for them being his own. However, some participants also highlighted times when there had been more blatant forms of bullying, including arguments with men in the workplace. This was highlighted by one participant who said that: *"I have once had a conflict with a senior colleague (a professor) that got a bit out of hand, where he on the phone strong-armed me and said he would personally take care I would not have [anything] to do with the topic-area about which we were in disagreement"* (ID12). Other individual challenges, included: (i) women scientists lacking confidence in their ability (N=7), (ii) limited acceptance of women leaders (N=8), (iii) sexual harassment and (iv) appearance (i.e. being judged on their physical characteristics). Finally, whilst mentioned less frequently, participants also outlined a range of institutional, financial and other gendered challenges (summarised in Table 2 and Table S4).

Enablers of women's leadership

Our third objective was to identify enablers of women's leadership, including the promotion, and subsequent success, of women's leadership (e.g. systems, processes and strategies). Participants were asked to suggest enablers that they had observed or applied as a leader, without having a list of enablers to select from. Thirty-three participants identified strategies and enablers that could be used to support women in leading interdisciplinary marine research. There were 25 subthemes, categorised as follows: (i) social, (ii) practical and process, (iii) institutional, (iv) individual, (v) financial and (vi) other (see Table 3). The ten most frequently mentioned enablers (or subthemes) are presented in Figure 2. Further information on each of the subthemes (with example quotes) are shown in Table S5 and S6.

The majority of participants highlighted social strategies or enablers (see Table S2). Of these, the most frequently mentioned subthemes were: (i) support and encouragement from superiors (N=21) and (ii) peers (N=16) and (iii) informal networking (N=14; Table 3). Participants perceived that support and encouragement from superiors was an important enabler: *"A leader that embraces and supports you makes a big difference"* (ID1). Participants highlighted the support they had received as part of their careers, as well as how they supported and encouraged their staff. This was followed by receiving support and encouragement from peers, which was mentioned by approximately half of participants. Many participants highlighted the value of being able to talk about their experiences with

other groups of women in similar contexts. The type of support and encouragement included giving staff or peers a safe space to discuss any issues; encouragement to apply for roles, promotion, leadership opportunities and awards; providing feedback (e.g. on research and development); acting as an advocate and increasing visibility. One participant stated *"We female-identifying scientists must support each other in getting forward with our careers instead of competing with each other"* (ID8).

Another enabler was informal networking, which included networking with colleagues in the workplace, as well as with the wider research community (e.g. at conferences, meetings, and via social media). One participant described how they had encouraged networking and connected her staff with researchers with similar interests: *"…let's get that person partnered with somebody with that knowledge or skill set, or, hey, let's go grab that person down the hall to have them interact with, or those sorts of things"* (ID14). Although mentioned less frequently, other social enablers included: formal networking (e.g. through established networks or organizations for women; N=7), role models (N=8), male allies (N=5) and gaining support and encouragement from family and friends (N=4).

Practical and process strategies were also commonly highlighted. Mentoring schemes were the most frequently mentioned enabler (N=14). As exemplified by one participant, *"No scientist can thrive in complete isolation, and none of the success I have experienced could have been achieved without supportive collaborators, mentors and organizations"* (ID10). Another identified enabler was the use of mechanisms to increase visibility and exposure of women scientists (e.g. through the media, social media, and on podcasts; N=9). Raising awareness and visibility of women scientists was perceived to increase career success, as well as to help promote the uptake of women academics into STEM. One participant stated that, *"…the advantage of being a lot in the press and getting a lot of public outreach done and being in the media, that sooner or later most people have heard about my work and then actually it's not so difficult anymore"* (ID30). The remaining practical strategies related to professional development. Specifically: (i) offering leadership training and schemes to women scientists (N=8), and (ii) offering planning and coaching to help women academics to achieve career progression (N=8).

Institutional strategies were also a commonly raised category, yielding seven subthemes (see Table 3). The implementation of diversity, equity and inclusion policies was seen as an important strategy (N=13), and included references to unconscious bias training, gender quotas, gender neutral applications, and equal pay. One participant stated "*In my university, we are strong in gender promotion and gender equality. We have a Gender and Development Office that ensures gender is mainstreamed in the policies, plans, activities"* (ID21). Creating a family-friendly environment within academic institutions (N=12) was seen as important. For example, by implementing measures such as affordable childcare, adopting flexible work practices and facilitating re-entry after maternity leave: "*I think that the universities should be more giving, they should give more support to mothers so that they can keep working, and not get so alone"* (ID29). Other institutional strategies included:

(i) improving academic or workplace culture (N=13), (ii) raising awareness and understanding of gender issues (N=8), (ii) providing women scientists with opportunities for leadership (N=9), (iii) increasing institutional support and capacity (N=7), and (iv) offering flexible working arrangements (N=5). Finally, individual, financial and other challenges were also discussed (summarised in Table 3 and Table S5 and S6).

Discussion

It is long established that a diversity of leaders is essential for identifying innovative solutions for complex environmental challenges[1,2]. This is particularly the case for interdisciplinary marine research, which draws on diverse forms of knowledge, methods and skillsets and mobilizes diverse networks, to navigate marine socio-ecological challenges[20]. Yet, women scientists are less likely to be in positions of leadership within academic interdisciplinary marine research institutions and projects compared to their male colleagues. This study sought to better understand the main barriers and enablers to women leadership's in interdisciplinary marine research. A broad framing of leadership was employed (i.e. leadership of research institutions, teams, projects or programs) reflecting the multi-dimensional nature of academic leadership and the cultural practice of different geographical contexts. This paper provides novel insights at the intersection between gender and interdisciplinarity within the context of marine science.

Challenges of interdisciplinary marine research

Through this study, we developed a comprehensive understanding of the main challenges and barriers of working in academia and undertaking interdisciplinary marine research, as perceived by women leaders. Leaders face a range of challenges stemming from their role in academia and interdisciplinary marine research. Many of these challenges are likely to be non-gendered. This finding is reinforced by previous research that has identified challenges faced by leaders (regardless of gender) working within academia more broadly [64,74,75]. It is unsurprising, as mechanisms within academia tend to reproduce dominant orders and persisting hierarchies and inequalities[76]. However, we acknowledge there may be some overlap with gendered challenges, as academic institutions, processes and careers have been described as gendered in multiple aspects[77].

Institutional barriers such as limited institutional support and capacity, academic or workplace culture, and institutional structure and policies were highlighted by participants. As highlighted previously, many barriers are embedded into institutional and departmental practices[55]. Leaders discussed the lack of available support and capacity within their institution (e.g. aiding research, teaching and administration) and the limited or restrictive institutional structure and policies, identified in previous research as hierarchical structures[78]. In combination, these two institutional challenges were perceived to affect a leader's ability to undertake research (e.g. due to lack of administrative support), apply for and successfully obtain funding, progress with their research goals, and undertake career

development. The leaders also experienced issues associated with academic or workplace culture. Previous research has shown that the academic culture in marine research[64] and other STEM disciplines more broadly, is associated with explicit and implicit norms such as long working hours and having high workloads[43].

The study results suggested that interdisciplinarity presents a significant barrier. This is due to the various disciplines and fields encompassed within interdisciplinary marine research (i.e. being a jack of all trades and keeping up with the literature), the upskilling required, the various actors to engage with (e.g. academic and stakeholder groups) and the time required to build effective interdisciplinary collaborations. There was also a perception of a lack of recognition and value attributed to interdisciplinary marine research. Interdisciplinary marine research was seen to be marginalised and underfunded in comparison to natural science disciplines. There were also challenges connected with working with researchers from other disciplines, due to differences in terminology, epistemologies and power relationships. Overall, the study suggested that interdisciplinary research presents an additional layer of complexity for scientists and can be more challenging and demanding than single-discipline research. This is consistent with the findings of previous studies examining interdisciplinarity in marine research[68] and in STEM more broadly[65,79–82]. For example, research suggests that interdisciplinary marine research is highly complex and presents a steep learning curve for both men and women, transitioning from single discipline science[64]. Furthermore, the multifaceted nature of interdisciplinary marine research can put academics at a disadvantage in terms of research productivity, when compared to single disciplinary science[83].

Third, we identified that not all leaders experience the same challenges, and that their individual experiences were dependent to some degree on the social environment they had worked and work in (i.e. social challenges[54]). Bias and prejudice can affect a scientist's workplace experiences and inhibit career progression, but the impact of 'glass ceilings' are more pronounced for specific groups. In line with previous research, challenges experienced by leaders were compounded when considering race, ethnicity, nationality, age and socio-economic status[33,84,85]. For instance, scientists belonging to minoritized groups can face a 'double bind' caused by the interplay between racism, sexism, and other systematic biases and cultural barriers[85–88]. Indeed, prior work suggests that minoritized groups are still underrepresented within marine research[89], government[27] and conservation and environmental organizations[90].

A lack of diversity in STEM can be attributed to gatekeeping, systemic issues of neo-colonial and globalization research practices and direct harm to individuals and groups[33]. Policies and management hierarchies can maintain the status quo, where the cultural majority remain in positions of power and dominance, similar to that where male hierarchies can lead to gendered monocultures. Cultural biases may disadvantage women and ethnic groups who do not model leadership behaviour on traditional white male styles of management[16,52]. Our study also highlighted the inequity between scientists in the

Global North and South, with the Global North being advantaged in terms of capacity, funding and publishing. These unequal research conditions have resulted in the phenomenon of parachute science[91], in addition to the underuse of non-English-language science[92]. Our findings are in line with earlier research which highlighted that the combination of persistent geographic bias has resulted in scientists in the Global South being significantly underrepresented in publishing, which may further contribute to their underrepresentation in future leadership positions[1,66]. Overall the lack of diversity and inclusion of underrepresented individuals and groups can lead to missed opportunities to harness the perspectives and ways of knowing held by diverse experts[33], which is required to advance social equity and address ocean sustainability challenges in the 21st century[93].

Gendered challenges experienced by women leaders

This study provides novel insights on the perceptions on intersection between gender and interdisciplinarity. Our exploratory study suggests that interdisciplinary marine research may be more challenging for women leaders, compared to men. Over 70% of women leaders perceived that interdisciplinary marine research was more challenging for women, as they experience a range of gendered barriers including expectations of women and a lack of trust and acceptance of women leaders (see below for further details). Previous research suggests that women are more drawn to interdisciplinary marine research, have various skills, values and behaviours that make them suited to this type of research[62] and can increase the success of interdisciplinary marine research[15]. Despite their suitability and expertise for interdisciplinary marine research, it appears that women leaders still face more challenges than men in the same field.

There was less agreement as to whether there were unique challenges for women scientists seeking to lead interdisciplinary marine research, compared to discipline-specific research. On the one hand, participants thought that interdisciplinary marine research presented additional challenges for women leaders. Interdisciplinary marine research is an emerging approach and presents further complexity for leaders and therefore increases work and mental loads (see 3.1). These challenges may be greater for women, due to the gendered challenges they face in the workplace as well as the domestic burden they experience. On the other hand, participants thought that interdisciplinary marine research wasn't any more challenging than discipline-specific research and actually may benefit women leaders. This reflects the findings of previous research[94]. Participants cited various reasons including: (i) interdisciplinary marine research being a newer, open and less competitive research area, (ii) there being higher diversity and representation in interdisciplinary marine research and (iii) interdisciplinary marine research being a more forward-looking and more fluid area, when compared to discipline-specific science.

The notion of barriers to women's leadership has received considerable attention in related fields (e.g. ecology and conservation[55]), STEM[54,84,95] and in academia more broadly[47,96]. Research is strong on

identifying barriers encountered by women scientists in academia, however, such research has rarely explored the barriers faced by women leaders in interdisciplinary contexts and within marine science. Reflecting the results of previous studies, we find that the majority of women have experienced a wide range of additional barriers and challenges owing to their gender (i.e. gendered challenges) [47,54,84,97]. This suggests that the barriers experienced within interdisciplinary marine research are of a similar nature to those encountered in other STEM fields. The women leaders articulated a wide range of barriers they had experienced, which together form the 'labyrinth' (also known as the 'glass obstacle course'[50]). These barriers affect their day-to-day role, mental wellbeing, job satisfaction, success and career progression[54,84,96]. Gendered barriers are socially constructed and reflect the societal views of what men and women should or should not be, or can and cannot do, and how people should relate to each other in households and society[98,99].

Social barriers were the most commonly discussed gendered challenge discussed by participants. In line with previous studies, women felt isolated and underrepresented, often due to the male-dominated environment (also referred to as the 'boys club' or 'old boys club'[70]) and lack of women scientists occupying upper divisions of academia. Prior research has shown that women scientists can face a 'chilly climate' when exposed to masculine institutional cultures and patriarchal systems[100–102]. These environments maintain male dominance and make it difficult for women scientists to feel comfortable and gain authority[103]. This has important implications, as women scientists may feel stressed, isolated, marginalized, demoralised and subsequently are demotivated from seeking career progression[27,104].

Gender stereotyping and expectations were also pervasive issues identified through our study. Stereotyping occurs when people assign characteristics to (members of) groups regardless of actual variation in people's characteristics. In agreement with previous research, participants recalled situations where they had observed or received subtle or blatant comments which reinforced stereotyping of who 'does' science[54]. These stereotypes reflect previous work in STEM[99,105–107]. Stereotypes paint women scientists as having low status and power which can lead to stigmatisation and for others to devalue them[43]. This is significant as it may make it more difficult for women academics to reach positions of leadership, gain respect, and influence and can prevent them from fully realising opportunities in their careers[108].

Women leaders in this study also contended with prejudice, due to biased expectations of how they should behave and the standards they should meet. This aligns with previous findings which show that women scientists face differential expectations and that double standards apply, meaning that for women to succeed they have to work harder than men in equivalent positions. Moreover, women face a higher bar to pass than men do to advance in their career[108]. Participants in our study perceived that they were subject to greater judgement and discussed the idea of a 'tightrope'. If they showed too much agency or confidence, they were described as 'bossy', but, if they were too communal, they were deemed an ineffective leader. Research has shown that successful women leaders often engender

hostility or are not liked and are judged for violating gender stereotypic expectations (i.e. 'backlash effects'[52,109]). Overall this can lead to fewer women taking on leadership roles, due to negative evaluations and/or the greater incidence of women being appointed to 'glass cliffs', which are situations associated with greater risk and more open to criticism[110].

Women leaders also identified two key practical and process challenges, which are consistent with the existing literature. First, the study highlighted that some of the challenges facing women are compounded due to parenthood and caring responsibilities and they have been disproportionately impacted during the COVID-19 pandemic. These findings are consistent with previous studies in STEM[53,84,111,112]. Participants highlighted that they often have to make a decision between work and being a mother, because research was often seen as incompatible with raising a family; a finding consistent with an earlier study[28]. The choice of having children or not was perceived to weigh more heavily on the career goals of women scientists, due to the disproportionate responsibility women assume for domestic duties. Additionally, it was perceived that parenthood had resulted in a slower rate of career advancement, due to balancing work and home life and it was often exacerbated by un-family-friendly structures and policies, the culture of academic institutions (e.g. long hours, required travel and relocation) and un-career-friendly family structures[113].

Women face social reproduction burden (or domestic burden), due to the unpaid and undervalued work that women undertake as mothers, carers and teachers, particularly during the COVID-19 pandemic[114]. This confirms the findings from previous research[43,84,115]. Slow career progression combined with an unsupportive environment has been shown to result in poorer research 'track records' for women scientists[83,116] and even abandonment of research careers[28]. Second, in this study, career progression was also perceived to be inhibited due to the often unseen and unsanctioned barriers which prevented women from securing leadership positions (i.e. 'the 'glass ceiling'[109,117]). There was a feeling that fewer women were being tapped on the shoulder compared to men and they were being excluded from career advancement opportunities. This affirms prior work which has identified the glass ceiling as a career hindering barrier in academia[47].

Taking the findings together, this study highlights that interdisciplinary marine research may be more challenging for women leaders, compared to men. Women leaders experience a host of challenges associated with working within academia and undertaking interdisciplinary marine research. These challenges exacerbate the existing gender-specific issues they experience in marine research[64]. Our study suggests that these barriers can overlap and intersect - and are particularly challenging for women in minoritized groups, due to prejudice, discrimination and inequality. More in-depth analysis is required to examine whether there are unique challenges for women scientists seeking to lead interdisciplinary marine research, compared to discipline-specific research. Overall, enablers are required to tackle the complex and diverse challenges facing women in interdisciplinary marine research.

Enablers of women's leadership

This study adds to the substantial evidence base documenting the barriers that women scientists experience in STEM, but focuses specifically on actionable strategies to support women leaders within academic interdisciplinary marine research institutions. Participants highlighted a range of formal and informal mechanisms for supporting women leaders.

Social enablers were the most frequently mentioned type of enabler, which aligns with previous research[49,70,95,116]. Previous studies suggest that support for women scientists comes from people, rather than training or institutional structures[84]. Participants reflected on the importance of having an internal and external network of support during their career and having role models and encouragement from various sources (e.g. from leaders, peers, male allies and family and friends[118,119]. For example, women leaders and role models can provide advice on how to successfully negotiate the academic labyrinth, increase empowerment, counteract the negative effects of stereotypes[21] and pave the way for women scientists that come after them.

Networking opportunities (informal and formal mechanisms) were also seen as an important social enabler for the promotion and success of women's leadership, consistent with previous findings[101,103,120]. Previous research suggests that career advancement is often dependent on building good social networks (or 'social capital') and can involve breaking into the 'boys club' or creating a women's club[51]. Networking can create a community of belonging and resistance[121], support women scientists in forging a scholarly identity[122] and provide them with information and material support (e.g. information relevant to career advancement[116,120]) and intellectual and political resources to deal with gender bias and discrimination[57]. Formal networks were discussed and included engaging with networks such as: (i) the Gender in Aquaculture and Fisheries network (GAFS), (ii) Organization for Women in Science (OSWD) and (iii) Women of the Reef. However, informal networks were mentioned more frequently. Women leaders predominantly discussed the significance of meeting and socialising with academic peers in the workplace. They highlighted the importance of informal networks for collaboration, as well as their role as a safe space for women to vent, share their experiences and discuss how to navigate being a woman and interdisciplinary scientist in marine research. Prior research has shown that women tend to underestimate their personal networks far more than men and that face-to-face meetings are important for developing women's networks[123]. These findings are particularly interesting, in a time when face-to-face networking has been limited due to the COVID-19 pandemic. It will be important to find out more about how this has impacted women's leadership and how the next generation of leaders will form such informal networks across disciplines.

Practical and process enablers were also important for supporting women's leadership and could help to reduce gender disparity within academic settings[103,124–126]. Practical strategies included mentoring,

raising the visibility and awareness of women scientists, professional development training (e.g. leadership and interdisciplinary research skills) and career planning and coaching. However, mentoring was the most popular strategy. Various forms of mentoring were discussed, including peer-, career development-, and/or personal mentor. Mentoring can be implemented by academic institutions, in addition to external organizations (e.g. learned societies and research networks). Mentoring is increasingly recognised as a critical element for supporting career progression[64,109], particularly for academics from minoritized or underrepresented groups[127,128]. Previous research suggests that mentees gain career development guidance, psychological and moral support and encouragement, it can increase their resilience[129] and sense of voice[130] and can alleviate their uncertainties about academic life[17]. Consequently, mentored academics are more likely to get promoted to positions of leadership, have increased commitment to the institution (i.e. reduced attrition) and receive more grant income[116,131,132].

Mentoring needs to be effective, rather than just existing as an institutional measure. Well designed and implemented mentoring can drive transformation towards a fair and safe scientific culture[16] and provide a significant return on investment[17,116]. Academic institutions that draw on best practices will be more likely to deliver successful, multidimensional and inclusive mentoring programs[16,133,134]. It is beyond the scope of this study to examine specific dimensions of successful mentoring practices and examples of effective programs. However, previous research has identified a range of attributes that are important for mentoring programs[135–139], for example: (i) integration of mentoring schemes into a broader program which targets institutional change in combination with improving women's individual development (i.e. the 'bifocal approach'), (ii) clear delivery objectives for the mentoring program (i.e. for the mentor, mentee and the institution), (iii) delivery of training sessions and resources for mentors and mentees within the program (e.g. development of mentoring skills, guidance on the mentor-mentee relationship and training around the challenges faced by women and minorities in academic institutions) and (iv) rigorous evaluation of the program. Successful mentorship is vital to career success and satisfaction for both mentors and mentees. Yet challenges continue to inhibit faculty members from receiving effective mentorship. Given the importance of mentorship on faculty members' careers, future studies must address the association between a failed mentoring relationship and a faculty member's career success, how to assess different approaches to mediating failed mentoring relationships, and how to evaluate strategies for effective mentorship throughout a faculty member's career.

Our study also highlighted the importance of institution-level enablers. Institutions are important for creating an inclusive and diverse research community and to overcome barriers experienced by academics and minoritized groups[7,48,140,141]. This includes the implementation of policies, systems and processes which address diversity, equity and inclusion (e.g. unconscious bias training, gender quotas, gender neutral applications and equal pay), which has previously been advocated for [8,11,142.] Although

766 mentioned by participants, alternative mechanisms to support women were more popular, i.e.
767 providing them with development opportunities, and improving the culture of academia within
768 interdisciplinary marine research. This is in line with previous research[22,143,144.]

769 Participants also highlighted the challenges they had faced during the COVID-19 pandemic and
770 encouraged the employment of policies which could help tackle inequalities associated with
771 parenthood and caring responsibilities. This included creating a family-friendly environment (e.g.
772 provision of affordable childcare) and offering flexible working for carers[22,53]. Research has shown
773 that such measures are essential for making leadership roles more accessible and inclusive[145] and in
774 recruiting, retaining and advancing high quality faculty staff[55]. They also highlighted the importance
775 of improving the academic or workplace culture for women leaders (e.g. providing a supportive
776 environment, asking individuals and groups to call out toxic behaviour and changing the culture of
777 working long hours). Research suggests that women have higher levels of job satisfaction,
778 productivity and less social isolation when working in a positive or supportive departmental
779 climate[146]. Other commonly discussed enablers included raising understanding and awareness of
780 gendered issues, offering more opportunities for women' leadership and increasing institutional
781 support and capacity (e.g. providing more administrative support), which have been acknowledged
782 previously[140,147].

783 **2.1.1. Applying enablers of women's leadership**

784 The enablers presented may help to progress towards gender equity and inclusion in interdisciplinary
785 marine research. A conscious and targeted approach will be important for creating an academic
786 environment which offers equal opportunities to women leaders and giving them the ability to
787 influence strategic decisions in marine research and beyond[22]. This research may have a variety of
788 applications at various scales (e.g. individual, project, team, department, program and institution-
789 level). These findings can serve as a roadmap for institutions wishing to promote and support
790 women's leadership in interdisciplinary marine research, particularly those from underrepresented
791 groups (e.g. ethnic minorities and scientists from the Global South). Institutional enablers in
792 particular, may aid planning and design of gender or broader Equity, Diversity and Inclusion action
793 plans. Institutions and the wider scientific community increasingly need to address deeply embedded
794 institutional and cultural issues and commit to increased action and accountability to accelerate
795 positive change[33].

796 In addition, these findings may also be useful at the individual level, for both women and men
797 wishing to enter leadership positions, or those currently in leadership positions. It may aid women in
798 identifying strategies for change and career development (e.g. training, mentoring and networking)
799 and help them to advocate for such opportunities within internal and external institutions. However,
800 gender equity is not a 'woman's problem'[54], women should not solely have the responsibility to

support one another[104]. Men will need to be allies and 'lean in' to their roles in addressing gender inequity in academia[148], as they have distinct opportunities to be influential advocates to create change[149].

In highlighting these enablers, we do not wish to deny the complexity of the gender-gap, the scale of gender discrimination in society and the cultural practice of different geographical contexts. Nor, do we imply that these enablers should serve as prescriptions of a set of strategies applicable in all contexts. Rather, we aim to highlight the range of potential options available for application at a variety of scales and call attention to the need to tackle the invisible and often unspoken challenges facing interdisciplinary marine leaders, particularly those from minoritized groups.

Limitations and future research

Through this study, we have developed a deeper understanding of the barriers and enablers of women's leadership in interdisciplinary marine research contexts. This study is exploratory in nature and is not comprehensive, nor is it intended to be. Therefore, there are important limitations to our study which are worth consideration. Reflecting on these limitations helps to provide recommendations for future research, which can further explore and tackle the gender inequity observed in interdisciplinary marine research and academia, more generally.

First, the barriers and enablers to women's leadership are based on the perceptions of a selection of women leaders working in academia and specialising in interdisciplinary marine research (see Table S1). We used a non-probability approach, purposive and snowballing techniques and had specific inclusion and exclusion criteria, hence, it is not a representative sample of the wider population of interdisciplinary marine women leaders. Nevertheless, this exploratory study provides a useful look into the types of barriers that may be experienced by women leaders and how to address these challenges in various interdisciplinary marine research settings. Future research is required to build on this study. Interdisciplinary marine research may have been a limiting concept and instead it may be organised in a different way across regions and cultures. Studies could focus on the barriers and enablers of women's leadership in geographic regions that are often underrepresented or excluded from interdisciplinary marine research (e.g. the Global South and non-OECD countries). For example, examining any regional differences in barriers and enablers (e.g. comparison of the Global North vs. Global South). This would provide valuable insights into geographic differences and provide recommendations on how to better foster and support gender and geographic representation within institutions and funding structures. In addition, the criteria excluded women leaders working on interdisciplinary marine research and practice in wider sectors, such as NGOs and government bodies. Therefore, researchers could explore the perception of women working in these broader interdisciplinary marine settings, who also have a key role in tackling ocean sustainability challenges.

Second, women leaders were invited to participate in and co-author this research (see Note S1). Our choice to collaboratively produce this research is consistent with a growing number of scholars who underscore the importance of co-producing gender research with those who have everyday, expert and/or scientific gender knowledge.This process can: (i) help to produce more rigorous knowledge of important practical experiences and (ii) flatten power hierarchies which can be felt within traditional research, as it brings in minoritized groups to the centre of knowledge produced about and by them [150,151]. Although every effort was made to reduce bias, inviting participants to be co-authors on the paper, may have influenced their responses to our questions about barriers and enablers of women's leadership.

Third, we examined: (i) challenges associated with academia and interdisciplinary marine research and (ii) gendered challenges experienced by women leaders. Challenges associated with academia and interdisciplinary marine research appear to be the non-gender specific barriers that participants had experienced as a leader. Such challenges have been discussed previously in the context of the academia and interdisciplinary marine research. However, given the exploratory nature of the study and survey sample it is impossible to confirm that they are ungendered. Further research could explore whether and the extent to which the academic and interdisciplinary challenges are also experienced by men (i.e. non-gendered) or whether they are gendered challenges. Moreover, the extent to which gendered challenges are being addressed within academic institutions across the world could be productively explored through future research.

Fourth, through this study, we elucidated a range of enablers for supporting women's leadership. However, we were unable to assign relative importance to, or the effectiveness of, each of the systems, processes and strategies identified in the study. Furthermore, we were unable to determine the career stage at which these enablers are most effective (i.e. early, mid and late career). Thus, whilst outside of the scope of this study, we believe that additional research is needed to evaluate the effectiveness of the enablers in practice, when applied at different career stages, to determine the most appropriate strategy or suite of approaches for promoting and supporting women's leadership in interdisciplinary marine research. This would also require the development of a holistic evaluation and monitoring program, building on literature examining the impact of interventions such as mentoring programs[16,127]. Interventions are gradually on the rise in various institutions, but their effectiveness has had little exploration.

Finally, we acknowledge that the articulation of women participants presents a potentially limited perspective of the barriers and enablers. Intersectionality issues emerged through the interview responses (i.e. coded as "social challenges"), which is reflective of the different experiences of participants, and aligns with research on intersectionality[140]. In the absence of nuanced detail, it enabled us to provide a higher level overview of the overlap between social categorizations such as gender, race, ethnicity, nationality and age, as they apply to groups of women leaders interviewed as

part of the research. Future studies may wish to focus specifically on intersectionality issues in interdisciplinary marine research and explore the issues raised here. For example, whether women with different academic positions or levels of leadership, ethnicities, cultural backgrounds and family circumstances (e.g. parent or carer) experience different barriers and enablers in interdisciplinary marine research.

Conclusion

Interdisciplinary marine research is and will continue to be paramount to addressing ocean sustainability challenges in the 21st century. The greatest innovation, science and discoveries will occur when academic institutions harness the power of diversity, of which gender is a critical component. However, to date, women leaders have been underrepresented in interdisciplinary marine research. Interdisciplinary marine research environments must become more gender inclusive, empowering and appealing places for women scientists to work. Through in-depth qualitative research, this exploratory study examines the main barriers and enablers to women's leadership in an interdisciplinary marine research context. The research identified that the majority of women leaders in this study experience a labyrinth of barriers and challenges, which have affected their day-to-day role, success and career progression. Leaders experience challenges associated with working in academia and undertaking interdisciplinary marine research and they are exacerbated by gendered barriers, facing women scientists. Our initial research suggests that these barriers overlap and intersect and are particularly challenging for women in underrepresented groups (e.g. ethnic minorities and leaders in the Global South). The study also articulated a range of enablers to promote and support women's leadership. They include: institutional reforms that affect the way both men and women work (e.g. parental leave), social support systems, mentoring and networking. The implementation of such enablers are not just the responsibility of the women. Gender inequality is a societal issue and targeted actions will need to be applied at various scales (e.g. individuals, teams, programs, departments, institutes, institutions) using both formal and informal mechanisms, to achieve transformative change. Going forward, these insights could be used to inform the design of gender equity initiatives, policies and frameworks that transform barriers into enablers of women's leadership, which make steps towards gender equality in interdisciplinary marine research and navigating contemporary challenges to marine socio-ecological systems.

Experimental procedures

Resource availability

Lead contact

Further information and requests for resources should be directed to and will be fulfilled by the Lead Contact, Rebecca Shellock (rebecca.shellock@anu.edu.au) .

Materials availability

This study did not generate new unique materials.

Data and Code Availability

The data underlying this article cannot be shared publicly due to privacy of individuals that participated in the study. The data will be shared on reasonable request to the corresponding author.

Choice of approach

We wanted to gain an in-depth understanding of experiences and perspectives of thirty-four global women leaders representing different nationalities, institutional contexts and types of leadership roles within academic interdisciplinary marine research organisations. A qualitative approach was selected due to the epistemological and ontological position of the study. Epistemology concerns the question of what is or should be regarded as acceptable knowledge in a discipline [152]. We aimed to produce rich and subjective data and were concerned with generating key concepts. Furthermore, we perceived that: (i) there would be multiple realities and truths based on individual constructions of reality and (ii) that realities are constantly changing and evolving [153]. This aligns with interpretivism and the 'qualitative' paradigm. The ontological position of the study also influenced how the research was formulated and delivered. Questions of ontology are concerned with the nature of social entities: (i) whether social entities can and should be considered objective entities that have a reality external to social actors, or (ii) whether they can and should be considered social constructions built up from the perceptions and actions of social actors[152]. We perceived that social phenomena from our study would be derived from social interactions which are continually changing (i.e. 'Constructionism'), which aligns with the ontological orientation commonly associated with qualitative research strategies [152,153].

Data collection

To address the objectives of this paper, the co-ordinating authors (RS, CC, MM, MCM, JB, RK, IvP, PT) engaged with women interdisciplinary marine research leaders from around the globe. In line with previous work[54], the common characteristic between all participants was their self-identification as a 'woman' in interdisciplinary marine research. While recruitment was for 'female identifying' participants, none of the participants were asked to disclose any detail about their gender identity. The use of 'woman' or 'women' in this study is acknowledged as presenting an inadequately binary view of gender. However, it is intended to encompass all expressions of female gender identities of the participants in the absence of nuanced detail. Future studies may wish to use a specific gender-identity frame of analysis to explore the issues raised here.

The study intended to explore the experiences and perceptions of being a woman leader in interdisciplinary marine research, using an intersectional lens. Intersectionality was first introduced by

939 Kimberlé Crenshaw in 1989[154] and is a *"theoretical framework for understanding how multiple social*
940 *identities such as race, gender, sexual orientation, socio-economic status, and disability intersect at*
941 *the micro level of individual experience to reflect interlocking systems of privilege and oppression*
942 *(i.e., racism, sexism, heterosexism, classism) at the macro social structural level"* [155] (p1267). Using
943 an intersectional lens, we can attempt to better articulate the invisible positions of women scientists
944 who experience multiple disadvantaged statuses[156,157].

945 A recruitment email was sent to all women leaders (see Note S1) and they were invited to participate
946 in this research and co-author subsequent publications. The survey was administered between January
947 and June 2021, and each leader had the option of answering the questions via semi-structured
948 interviews (N=8) or by providing a written response (N=25). In the case of interviews, the questions
949 were shared with the participants in advance to allow them time to carefully consider their responses
950 and to provide in-depth recollections of their experiences. The interviews were conducted over Zoom
951 and Webex and lasted on average 55 minutes (ranging from 33-69 minutes).

952 The study employed an information-oriented, maximum variation approach to sampling (based on
953 [158]). The goal of this sampling strategy was not to include all women leaders working in academic
954 interdisciplinary marine research. Instead, it was used to ensure the inclusion of a variety of
955 perspectives and exploration into the types of barriers that may be experienced by women leaders and
956 how to address these challenges in various interdisciplinary marine research settings. The cases were
957 selected on the basis of maximising diversity of participants (i.e. diversity of leadership, disciplines
958 and geographic regions) and ensuring the inclusion of diverse perspectives, to avoid overlap in
959 geographic areas and where participants were most accessible to the research team (e.g. due to
960 logistical constraints, the study was undertaken in English[159]). The co-ordinating authors identified
961 relevant participants through 'purposive' and 'snowball' sampling, which are widely employed
962 methods of sampling in qualitative research[152,160]. The following criteria was used to select
963 participants for the study: (i) they held a form of leadership role at any level (i.e. leading a research
964 institution, team, project or program), (ii) they worked within an academic institution and (iii) their
965 research focused on marine socio-ecological systems. A broader definition of leadership (and hence
966 criteria) was selected for two reasons. Firstly, due to the multi-dimensional nature of leadership within
967 academia, which varies across regions and cultures. Second, previous research suggests that there are
968 still relatively few women reaching more senior positions of leadership (e.g. leading research
969 institutions)[22]. This wider definition of leadership enabled us to understand the barriers and enablers
970 to various leadership roles that women have secured in the field and this also aided data collection.

971 Purposive sampling is a form of non-probability sampling and it was used to sample participants who
972 were relevant to the topic and fit a specific profile[161], so that those sampled were relevant to the
973 research questions being posed[152]. We first targeted women leaders within the co-ordinating author's
974 professional networks (and web searches) and then asked those participants to share contacts who

they believed would be relevant to the study. This step was also used to identify women leaders in underrepresented geographic locations during the first stage (including Africa, Asia and Latin America and the Caribbean). This was repeated at the end of each subsequent interview and prospective participants were invited to participate. Leaders were contacted if they met the aforementioned criteria. Overall, 25 participants were identified by the co-ordinating authors, with a total of 21 taking part in the study. This approach was selected as there was no accessible sampling frame for the population from which the sample is to be taken [152]. Furthermore, by virtue of there being fewer women leaders, the network of interdisciplinary marine women leaders is subsequently quite small, hence, this was the most feasible approach. This was supplemented by 12 participants identified through the snowballing technique, who were selected based on the criteria.

The co-ordinating authors made a concerted effort to identify women leaders across the world, but there were challenges with identifying participants in specific regions (e.g. Africa and the Middle East). This may be attributed to the personal networks of the co-ordinating authors and participants and the inclusion and exclusion criteria set for the study. The criteria excluded women leaders working on interdisciplinary marine research and practice in wider sectors, such as NGOs and government bodies. In addition, interdisciplinary marine research may have been a limiting concept and instead it may be organised in a different way across regions and cultures. As highlighted previously, expansion of interdisciplinary marine research (e.g. Marine Social Science) has predominantly been focused within academic institutions in Western regions [68]. Overall, as a result of this approach to sampling, the thirty-four cases spanned twenty-seven countries (see Table S1).

Survey instrument

A qualitative research approach was adopted in this study to provide a more in-depth and comprehensive exploration of the three study objectives. Qualitative approaches have been employed in similar studies, for example, in identifying strategies for building and managing trust at the marine-science-policy interface[162] and tips for developing interdisciplinary socio-ecological researchers[61]. A survey instrument was developed by co-ordinating authors to ensure a consistent approach and was produced in two forms: (i) self-completion survey and (ii) interview guide. Questions pertained to: (i) the main barriers and challenges that they had experienced as a leader in academia and interdisciplinary marine research contexts (ii) the main gender-based barriers and challenges that they had experienced as a woman leader in academia and interdisciplinary marine research contexts and (iii) the strategies or enablers that can be used to successfully develop women scientists in leading interdisciplinary marine research (see survey instrument; Note S2). Participants were asked about the main barriers and challenges they had experienced as a leader. This question helped to us to understand the broader range of issues that women leaders had experienced in academic institutions and to examine the multiple disadvantaged or minoritized statuses (i.e. intersectionality). This was followed by a question that focused specifically on gendered challenges (i.e. those experienced due to

being a woman leader in academia). Qualitative pre-testing was undertaken to ensure the adequacy of the survey instrument (e.g. providing insights into participants' comprehension of the materials). The guide was peer-reviewed by three external researchers specialising in marine social science and was piloted among the co-ordinating authors and refined accordingly. Minor changes to language and wording were made to the guide to improve the clarity and context specificity of questions. This was particularly important, as for many participants, English was not their first language. Data collection was undertaken by seven of the eight co-ordinating authors (RS, CC, MM, MCM, JB, RK and IvP).

Data analysis

Interview transcripts were professionally transcribed to ensure their accuracy. The transcripts and written responses were then analysed using NVIVO 12 qualitative data analysis software. The research objectives formed the basis of the coding, and the analysis of raw data was completed following an inductive approach, based on Grounded Theory Analysis [163]. Based on best practice, there were three main stages to data analysis[164]. The first was initial coding. The purpose of initial coding was to start the process of categorisation and assigning meaning to the data, comparing incident-to-incident, and to look for emergent patterns in the data[165]. The raw data (surveys and interview transcripts) were broadly coded against the three research objectives. Each transcript was coded against a set of descriptors designed to identify emergent themes and to capture the key elements of these themes [152]. Using participants' own words to derive and summarize key themes ("in vivo" coding) allowed the research findings (key themes) to emerge naturally from the interviews, without the restrictions imposed by more structured methodologies[166]. Hence, the results are a direct reflection of the language and words commonly used by the research participants, as opposed to the potentially subjective interpretations of the co-ordinating authors[167].

The second stage was focused coding. During this process, the researchers pursued a selected set of central codes throughout the entire dataset and study. This required decisions to be made on which initial codes were most prevalent or important, and made the most analytical sense to ensure data were categorised incisively and completely (i.e. assessing the adequacy of codes from the initial coding stage[164,167]). The third stage was theoretical coding. Theoretical coding integrated and synthesised the categories derived from coding and analysis. Initial coding fractures the data while theoretical codes *"weave the fractured story back together again"* [168] (p72) in order to identify key themes and concepts[152]. This stage resulted in the barriers and enablers being categorised into eight themes (where applicable), and was based on previous research[169,170]. They included: (i) practical and process (i.e. the implementation and application of actions, rather than theory and ideas), (ii) institutional (i.e. relating to academic interdisciplinary marine research institutions), (iii) social (i.e. stemming from social interactions and networks within the academic or workplace environment), (iv) financial (i.e. connected to the availability and suitability of funding), (v) material (i.e. related to materials, such as

documents and social media), (vi) individual (i.e. at the personal level), (vii) political (i.e. associated with policy and decision-making), (viii) other (i.e. miscellaneous topics).

Two practices were undertaken to ensure the validity of the emerging themes and subthemes. First, three of the co-ordinating authors (RS, CC and MM) each performed initial coding for a subset of the transcripts (N=5), which were selected based on the level of detail and length of the interviews with the assumption they would cover most themes[171]. Collective author reflection on the themes during the group synthesis and preparation of this paper further verified their relevance and value. The co-ordinating authors then collectively discussed and further refined the findings, before distributing them to study participants[161]. Second, the themes were continually verified against the raw data from which they were derived (following previous studies, e.g.[161,172]). This iterative process aided the development of a coherent synthesis of key themes (and subthemes)[173,174]. Data analysis was undertaken by the lead author to maintain independence of interpretation. All 34 of the participants were included as co-authors on the paper and they were involved in the validation and interpretation of findings (i.e. 'respondent validation'). Participants did not have access to the data and were unable to modify the results. Instead, they validated and interpreted the findings by providing written feedback on the draft manuscripts (e.g. adding additional text to aid interpretation of the data) or by discussing the findings with the lead author. This is in line with best practice, which recommends sharing findings and providing participants with the opportunity to clarify, corroborate or approve the findings[152].

Acknowledgements

We thank Katherine Maltby, Sara Mynott and Natasha Simmonds for providing feedback on and piloting the interview guide. We also thank S.A. McCormack (Visual Knowledge) for the development of Figures 1 and 2. We also thank the three anonymous reviewers for their comments that helped to improve the paper. AB thanks CNPq for a productivity scholarship grant (# 301592/2017-9).). GHC would like to acknowledge the support by funding in part from the Global Challenges Research Fund (GCRF) via the United Kingdom Research and Innovation (UKRI) under grant agreement NE/P021107/1 to the Blue Communities project, which is partially hosted by the Universiti Malaya under reference no. IF052-2017. MS-M acknowledge support from the Norwegian Research Council, grant no 288192 (BarentsRISK). NV was supported by a grant of the Romanian Ministry of Education and Research, CNCS - UEFISCDI, project number PN-III-P1-1.1-TE-2019-1444, within PNCDI III and the project T4BS (grant no. EASME/EMFF/2019/863621). MSW acknowledges the MISSION ATLANTIC project funded by the European Union's Horizon 2020 Research and Innovation Program under grant agreement No. 639 862428.

Author contributions

Conceptualization, R.J.S, C.C., M.M., M.C.M., J.B., R.K. IvP; Methodology, R.J.S, C.C., M.M., M.C.M., J.B., R.K., IvP; Investigation, R.J.S, C.C., M.M., M.C.M., J.B., R.K., IvP; Formal analysis: R.J.S, C.C., M.M., M.C.M.; Validation, all authors; Writing – Original draft: R.J.S. Writing- Review & Editing, all authors.

Declaration of interests

The authors declare no competing interests.

References

1. Maas, B., Pakeman, R.J., Godet, L., Smith, L., Devictor, V., and Primack, R. (2021). Women and Global South strikingly underrepresented among top-publishing ecologists. Conserv. Lett., 1–9.

2. Jimenez, M.F., Laverty, T.M., Bombaci, S.P., Wilkins, K., Bennett, D.E., and Pejchar, L. (2019). Underrepresented faculty play a disproportionate role in advancing diversity and inclusion. Nat. Ecol. Evol. *3*, 1030–1033.

3. Nash, K.L., Cvitanovic, C., Fulton, E.A., Halpern, B.S., Milner-Gulland, E.J., Watson, R.A., and Blanchard, J.L. (2017). Planetary boundaries for a blue planet. Nat. Ecol. Evol. *1*, 1625–1634.

4. Claudet, J. (2021). The seven domains of action for a sustainable Ocean. Cell *184*, 1426–1429.

5. Nash, K.L., Blythe, J.L., Cvitanovic, C., Fulton, E.A., Halpern, B.S., Milner-Gulland, E.J., Addison, P.F.E., Pecl, G.T., Watson, R.A., and Blanchard, J.L. (2020). To Achieve a Sustainable Blue Future, Progress Assessments Must Include Interdependencies between the Sustainable Development Goals. One Earth *2*, 161–173.

6. Gissi, E., Portman, M.E., and Hornidge, A.K. (2018). Un-gendering the ocean: Why women matter in ocean governance for sustainability. Mar. Policy *94*, 215–219.

7. Nielsen, W., Alegria, S., Börjeson, L., Falk-krzesinski, H.J., Joshi, A., Leahey, E., Smith-doerr, L., and Woolley, A.W. (2017). Correction: Gender diversity leads to better science (Proceedings of the National Academy of Sciences of the United States of America (2017) 114 (1740-1742) DOI: 10.1073/pnas.1700616114). Proc. Natl. Acad. Sci. U. S. A. *114*, E2796.

8. UNESCO (2017). Cracking the Code: Girls' and Womens' Education in Science, Technology, Engineering and Mathematics (STEM) Technical Report.

9. Singh, G.G., Cisneros-Montemayor, A.M., Swartz, W., Cheung, W., Guy, J.A., Kenny, T.A., McOwen, C.J., Asch, R., Geffert, J.L., Wabnitz, C.C.C., et al. (2018). A rapid assessment of co-benefits and trade-offs among Sustainable Development Goals. Mar. Policy *93*, 223–231.

10. Claudet, J., Bopp, L., Cheung, W.W.L., Devillers, R., Escobar-Briones, E., Haugan, P., Heymans, J.J., Masson-Delmotte, V., Matz-Lück, N., Miloslavich, P., et al. (2020). A Roadmap for Using the UN Decade of Ocean Science for Sustainable Development in Support of Science, Policy, and Action. One Earth *2*, 34–42.

11. Australian Academy of Science (2019). Women in STEM Decadal Plan.

12. UN (2015). Transforming Our World: The 2030 Agenda for Sustainable Development.

13. Østergaard, C.R., Timmermans, B., and Kristinsson, K. (2011). Does a different view create something new? the effect of employee diversity on innovation. Res. Policy *40*, 500–509.

14. Bear, J.B., and Woolley, A.W. (2011). The role of gender in team collaboration and performance. Interdiscip. Sci. Rev. *36*, 146–153.

15. Blythe, J., and Cvitanovic, C. (2020). Five Organizational Features That Enable Successful Interdisciplinary Marine Research. Front. Mar. Sci. *7*.

16. Davies, S.W., Putnam, H.M., Ainsworth, T., Baum, J.K., Bove, C.B., Crosby, S.C., Côté, I.M., Duplouy, A., Fulweiler, R.W., Griffin, A.J., et al. (2021). Promoting inclusive metrics of success and impact to dismantle a discriminatory reward system in science. PLOS Biol. *19*, e3001282.

17. Schmidt, E.K., and Faber, S.T. (2016). Benefits of Peer Mentoring to Mentors, Female Mentees and Higher Education Institutions. Mentor. Tutoring Partnersh. Learn. *24*, 137–157.

18. Ranganathan, M., Lalk, E., Freese, L.M., Freilich, M.A., Wilcots, J., Duffy, M.L., and Shivamoggi, R. (2021). Trends in the Representation of Women Among US Geoscience Faculty From 1999 to 2020: The Long Road Toward Gender Parity. AGU Adv. *2*, 1–14.

19. Liverman, D., Nying, P., Stendahl, K., Gay-antaki, M., Craig, M., Bynoe, P., Call, F., Connors, S., David, L., Hayward, B., et al. (2022). Survey of gender bias in the IPCC. Nature *602*, 30–32.

20. Christie, P. (2011). Creating space for interdisciplinary marine and coastal research: Five dilemmas and suggested resolutions. Environ. Conserv. *38*, 172–186.

21. Latu, I.M., Mast, M.S., Lammers, J., and Bombari, D. (2013). Successful female leaders empower women's behavior in leadership tasks. J. Exp. Soc. Psychol. *49*, 444–448.

22. Giakoumi, S., Pita, C., Coll, M., Fraschetti, S., Gissi, E., Katara, I., Lloret-Lloret, E., Rossi, F., Portman, M., Stelzenmüller, V., et al. (2021). Persistent gender bias in marine science and conservation calls for action to achieve equity. Biol. Conserv. *257*, 109134.

23. Martin, L.J. (2012). Where are the women in ecology? Front. Ecol. Environ. *10*, 177–178.

24. Larivière, V., Ni, C., Gingras, Y., Cronin, B., and Sugimoto, C.R. (2013). Global gender disparities in science. Nat. News *504*, 211.

25. Gillanders, B.M., and Heupel, M.R. (2019). Women in marine science in Australia. Mar. Freshw. Res. *70*, i.

26. Pell, A.N. (1996). Fixing the Leaky Pipeline: Women Scientists in Academia. J. Anim. Sci. *74*, 2843–2848.

27. Arismendi, I., and Penaluna, B.E. (2016). Examining diversity inequities in fisheries science: A call to action. Bioscience *66*, 584–591.

28. Shen, H. (2013). Mind the (gender) gap. Nature *495*, 22–24.

29. Cowper-Coles, M., Glennie, M., Mendes, B., and Schmid, C. (2021). Bridging the gap? An analysis of gender pay gap reporting in six countries.

30. Ley, T.J., and Hamilton, B.H. (2008). Sociology: The gender gap in NIH grant applications. Science (80-.). *322*, 1472–1474.

31. Sanderson, K. (2021). Researchers voice dismay at all-male science Nobels. Nature.

32. Cho, A.H., Johnson, S.A., Schuman, C.E., Adler, J.M., Gonzalez, O., Graves, S.J., Huebner, J.R., Blaine Marchant, D., Rifai, S.W., Skinner, I., et al. (2014). Women are underrepresented on the editorial boards of journals in environmental biology and natural resource management. PeerJ *2014*, 1–11.

33. Ahmadia, G.N., Cheng, S.H., Andradi-brown, D.A., Baez, S.K., Barnes, M.D., Bennett, N.J., Campbell, S.J., Darling, E.S., Gill, D., Gress, E., et al. (2021). Limited Progress in Improving Gender and Geographic Representation in Coral Reef Science. Front. Mar. Sci. *8*, 1–15.

34. Bendels, M.H.K., Müller, R., Brueggmann, D., and Groneberg, D.A. (2018). Gender disparities in high-quality research revealed by Nature Index journals. PLoS One *13*, e0189136.

35. Huang, J., Gates, A.J., Sinatra, R., and Barabási, A.L. (2020). Historical comparison of gender inequality in scientific careers across countries and disciplines. Proc. Natl. Acad. Sci. U. S. A. *117*, 4609–4616.

36. Hagan, A.K., Topçuoğlu, B.D., Gregory, M.E., Barton, H.A., and Schloss, P.D. (2020). Women Are Underrepresented and Receive Differential Outcomes at ASM Journals: a Six-Year Retrospective Analysis. MBio *11*, e01680-20.

37. Fox, C.W., and Paine, C.E.T. (2019). Gender differences in peer review outcomes and manuscript impact at six journals of ecology and evolution. Ecol. Evol. *9*, 3599–3619.

38. Niriella, M.A., De Silva, A.P., de Silva, H.J., and Jayasinghe, S. (2020). Is there racism in academic medical publishing?'. BMJ Evidence-Based Med.

39. Holman, L., Stuart-Fox, D., and Hauser, C.E. (2018). The gender gap in science: How long until women are equally represented? PLoS Biol. *16*, 1–20.

40. Greider, C.W., Sheltzer, J.M., Cantalupo, N.C., Copeland, W.B., Dasgupta, N., Hopkins, N., Jansen, J.M., Joshua-Tor, L., McDowell, G.S., Metcalf, J.L., et al. (2019). Increasing gender diversity in the STEM research workforce. Science (80-.). *366*, 692–695.

41. Hering, J.G. (2019). Women as leaders in academic institutions: Personal experience and narrative literature review. Pure Appl. Chem. *91*, 331–338.

42. Michalena, E., Straza, T.R.A., Singh, P., Morris, C.W., and Hills, J.M. (2020). Promoting sustainable and inclusive oceans management in Pacific islands through women and science. Mar. Pollut. Bull. *150*, 110711.

43. Hoyt, C.L. (2010). Women, Men, and Leadership: Exploring the Gender Gap at the Top. Soc. Personal. Psychol. Compass *4*, 484–498.

44. Barber, P.H., Hayes, T.B., Johnson, T.L., Márquez-Magaña, L., and 10, 234 signatories (2020). Systemic racism in higher education. Science (80-.). *10*, 1440–1441.

45. Bala Chaudhary, V., and Berhe, A.A. (2020). Ten simple rules for building an antiracist lab. PLoS Comput. Biol. *16*, 1–9.

46. Women in Ocean Science CIC (2021). Sexual Harassment in Marine Science.

47. Kalaitzi, S., Czabanowska, K., Fowler-Davis, S., and Brand, H. (2017). Women leadership barriers in healthcare, academia and business. Equal. Divers. Incl. *36*, 457–474.

48. Kern, C.C., Kenefic, L.S., and Stout, S.L. (2015). Bridging the Gender Gap: The Demographics of Scientists in the USDA Forest Service and Academia. Bioscience *65*, 1165–1172.

49. Kong, S., Carroll, K., Lundberg, D., Omura, P., and Lepe, B. (2020). Reducing gender bias in STEM. MIT Sci. Policy Rev. *1*, 55–63.

50. De Welde, K., and Laursen, S. (2011). The glass obstacle course: Informal and formal barriers for women Ph. D. students in STEM fields. Int. J. Gender, Sci. Technol. *3*, 571–595.

51. Eagly, A.., and Carli, L.. (2007). Through the Labyrinth: The Truth about how Women Become Leaders (Harvard Business School Press).

52. Rudman, L.A., Moss-Racusin, C.A., Phelan, J.E., and Nauts, S. (2012). Status incongruity and backlash effects: Defending the gender hierarchy motivates prejudice against female leaders. J.

Exp. Soc. Psychol. *48*, 165–179.

53. Fulweiler, R.W., Davies, S.W., Biddle, J.F., Burgin, A.J., Cooperdock, E.H.G., Hanley, T.C., Kenkel, C.D., Marcarelli, A.M., Matassa, C.M., Mayo, T.L., et al. (2021). Rebuild the Academy: Supporting academic mothers during COVID-19 and beyond. PLoS Biol. *19*, 1–11.

54. O'Connell, C., and McKinnon, M. (2021). Perceptions of Barriers to Career Progression for Academic Women in STEM. societies *11*, 27.

55. Mitchneck, B., Smith, J.L., and Latimer, M. (2016). A recipe for change: Creating a more inclusive academy. Science (80-.). *352*, 148–149.

56. Botella, C., Rueda, S., López-Iñesta, E., and Marzal, P. (2019). Gender diversity in STEM disciplines: A multiple factor problem. Entropy *21*.

57. Macoun, A., and Miller, D. (2014). Surviving (thriving) in academia: Feminist support networks and women ECRs. J. Gend. Stud. *23*, 287–301.

58. McKinley, E., Acott, T., and Yates, K.L. (2020). Marine social sciences: Looking towards a sustainable future. Environ. Sci. Policy *108*, 85–92.

59. Crow, M.M., and Dabars, W.B. (2017). Interdisciplinarity and the institutional context of knowledge in the American research university. In The Oxford handbook of interdisciplinarity, R. Frodemen and J. T. Klein, eds. (Oxford University Press), pp. 471–484.

60. Cooke, S.J., Nguyen, V.M., Anastakis, D., Scott, S.D., Turetskyd, M.R., Amirfazli, A., Hearn, A., Milton, C.E., Loewen, L., Smith, E.E., et al. (2020). Diverse perspectives on interdisciplinarity from Members of the College of the Royal Society of Canada. Facets *5*, 138–165.

61. Kelly, R., Mackay, M., Nash, K.L., Cvitanovic, C., Allison, E.H., Armitage, D., Bonn, A., Cooke, S.J., Frusher, S., Fulton, E.A., et al. (2019). Ten tips for developing interdisciplinary socio-ecological researchers. Socio-Ecological Pract. Res. *1*, 149–161.

62. Rhoten, D., and Pfirman, S. (2007). Women in interdisciplinary science: Exploring preferences and consequences. Res. Policy *36*, 56–75.

63. Ledford, H. (2015). Team Science. Nature *528*, 308–311.

64. Andrews, E.J., Harper, S., Cashion, T., Palacios-Abrantes, J., Blythe, J., Daly, J., Eger, S., Hoover, C., Talloni-Alvarez, N., Teh, L., et al. (2020). Supporting early career researchers: Insights from interdisciplinary marine scientists. ICES J. Mar. Sci. *77*, 476–485.

65. Hein, C.J., Ten Hoeve, J.E., Gopalakrishnan, S., Livneh, B., Adams, H.D., Marino, E.K., and Susan Weiler, C. (2018). Overcoming early career barriers to interdisciplinary climate change research. Wiley Interdiscip. Rev. Clim. Chang. *9*, 1–18.

66. Schipper, E.L.F., Ensor, J., Mukherji, A., Mirzabaev, A., Fraser, A., Harvey, B., Totin, E., Garschagen, M., Pathak, M., Antwi-Agyei, P., et al. (2021). Equity in climate scholarship: a manifesto for action. Clim. Dev. *0*, 1–4.

67. Blythe, J., Nash, K., Yates, J., and Cumming, G. (2017). Feedbacks as a bridging concept for advancing transdisciplinary sustainability research. Curr. Opin. Environ. Sustain. *26–27*, 114–119.

68. McKinley, E., Kelly, R., Mackay, M., Shellock, R., Cvitanovic, C., and van Putten, I. Development and Expansion in the Marine Social Sciences: Insights from the Global Community. Available SSRN 3956820.

69. Bottrill, M.C., Joseph, L.N., Carwardine, J., Bode, M., Cook, C., Game, E.T., Grantham, H., Kark, S., Linke, S., McDonald-Madden, E., et al. (2008). Is conservation triage just smart decision making? Trends Ecol. Evol. *23*, 649–654.

70. Jones, M.S., and Solomon, J. (2019). Challenges and supports for women conservation leaders. Conserv. Sci. Pract. *1*, e36.

71. Gabster, B.P., van Daalen, K., Dhatt, R., and Barry, M. (2020). Challenges for the female academic during the COVID-19 pandemic. Lancet *395*, 1968–1970.

72. Deryugina, T., Shurchkov, O., and Stearns, J. (2021). COVID-19 Disruptions Disproportionately Affect Female Academics. AEA Pap. Proc. *111*, 164–168.

73. Lutzky, U., and Lawson, R. (2019). Gender Politics and Discourses of #mansplaining, #manspreading, and #manterruption on Twitter. Soc. Media Soc. *5*.

74. OECD (2021). Challenges and new demands on the academic research workforce. In OECD Science, Technology and Innovation Outlook 2021: Times of Crisis and Opportunity (OECD Publishing).

75. Pannell, J.L., Dencer-Brown, A.M., Greening, S.S., Hume, E.A., Jarvis, R.M., Mathieu, C., Mugford, J., and Runghen, R. (2019). An early career perspective on encouraging collaborative and interdisciplinary research in ecology. Ecosphere *10*.

76. Bourdieu, P. (1997). The Forms of Capital. In Education, Culture. Economy, and Society, A. H. Halsey, H. Lauder, and P. Brown, eds. (Oxford University Press).

77. Acker, J. (1990). Hierarchies, jobs, bodies: A theory of gendered organizations. Gend. Soc. *4*, 139–158.

78. Chesterman, C., Ross-Smith, A., and Peters, M. (2003). Changing the Landscape? Women in academic leadership in Australia. McGill J. Educ. *38*, 421–435.

79. Schuitema, G., and D. Sintov, N. (2017). Should we quit our jobs? Challenges, barriers and

recommendations for interdisciplinary energy research. Energy Policy *101*, 246–250.

80. Moon, K., Cvitanovic, C., Blackman, D.A., Scales, I.R., and Browne, N.K. (2021). Five Questions to Understand Epistemology and Its Influence on Integrative Marine Research. Front. Mar. Sci. *8*, 1–9.

81. Brown, R.R., Deletic, A., and Wong, T.H.F. (2015). How to catalyse collaboration. Nature *525*, 315–317.

82. Bromham, L., Dinnage, R., and Hua, X. (2016). Interdisciplinary research has consistently lower funding success. Nature *534*, 684–687.

83. Corley, E.A. (2005). How do career strategies, gender, and work environment affect faculty productivity levels in university-based science centers? Rev. Policy Res. *22*, 637–655.

84. McCullough, L. (2020). Barriers and assistance for female leaders in academic stem in the US. Educ. Sci. *10*, 1–13.

85. Sanchez-Hucles, J. V., and Davis, D.D. (2010). Women and Women of Color in Leadership: Complexity, Identity, and Intersectionality. Am. Psychol. *65*, 171–181.

86. Bumpus, N. (2020). Too many senior white academics still resist recognizing racism. Nature *583*, 661.

87. Calaza, K.C., Daflon, V.T., David, I.P.A., Castro, H.C., Vargas, M.D., Martins, L.B., and Stariolo, J.B. (2021). Facing Racism and Sexism in Science by Fighting Against Social Implicit Bias: A Latina and Black Woman's Perspective. Front. Psychol. *12*, 1–9.

88. Liani, M.L., Nyamongo, I.K., and Tolhurst, R. (2020). Understanding intersecting gender inequities in academic scientific research career progression in sub-Saharan Africa. Int. J. Gend. *12*, 262–288.

89. Roberts, C. (2020). Diversity, equality and inclusion in marine science. Mar. Biol., 28–29.

90. Taylor, D.E. (2014). The State of Diversity in Environmental Organizations: Mainstream NGOs, Foundations & Government Agencies. 28–31.

91. Stefanoudis, P. V., Licuanan, W.Y., Morrison, T.H., Talma, S., Veitayaki, J., and Woodall, L.C. (2021). Turning the tide of parachute science. Curr. Biol. *31*, R184–R185.

92. Amano, T., Berdejo-Espinola, V., Christie, A.P., Willott, K., Akasaka, M., Báldi, A., Berthinussen, A., Bertolino, S., Bladon, A.J., Chen, M., et al. (2021). Tapping into non-English-language science for the conservation of global biodiversity. PLOS Biol. *19*, e3001296.

93. Bennett, N.J., Katz, L., Yadao-Evans, W., Ahmadia, G.N., Atkinson, S., Ban, N.C., Dawson,

N.M., de Vos, A., Fitzpatrick, J., and Gill, D. (2021). Advancing social equity in and through marine conservation. Front. Mar. Sci., 994.

94. Mitchell, A. (1999). UK women lead the way on interdisciplinary research. Nature *397*, 282.

95. Babalola, O.O., Du Plessis, Y., and Babalola, S.S. (2021). Insight into the organizational culture and challenges faced by women stem leaders in Africa. Soc. Sci. *10*.

96. Francis, L., and Stulz, V. (2020). Barriers and facilitators for women academics seeking promotion. Aust. Univ. Rev. *62*, 47–60.

97. Howe-Walsh, L., and Turnbull, S. (2016). Barriers to women leaders in academia: tales from science and technology. Stud. High. Educ. *41*, 415–428.

98. Lawless, S., Cohen, P.J., Mangubhai, S., Kleiber, D., and Morrison, T.H. (2021). Gender equality is diluted in commitments made to small-scale fisheries. World Dev. *140*, 105348.

99. Muñoz Boudet, A.M., Petesch, P., Turk, C., and Thumala, A. (2013). On Norms and Agency: Conversations about Gender Equality with Women and Men in 20 Countries. Directions in Development.

100. Yousaf, R., and Schmiede, R. (2017). Barriers to women's representation in academic excellence and positions of power. Asian J. Ger. Eur. Stud. *2*.

101. Harris, C., Ravenswood, K., and Myers, B. (2013). Glass slippers, Holy Grails and Ivory Towers: gender and advancement in academia. Labour Ind. a J. Soc. Econ. relations Work *23*, 231–244.

102. Cyr, E.N., Bergsieker, H.B., Dennehy, T.C., and Schmader, T. (2021). Mapping social exclusion in STEM to men's implicit bias and women's career costs. Proc. Natl. Acad. Sci. *118*, e2026308118.

103. Casad, B.J., Franks, J.E., Garasky, C.E., Kittleman, M.M., Roesler, A.C., Hall, D.Y., and Petzel, Z.W. (2021). Gender inequality in academia: Problems and solutions for women faculty in STEM. J. Neurosci. Res. *99*, 13–23.

104. Born, A., Ranehill, E., and Sandberg, A. (2018). A Man's World? The Impact of a Male Dominated Environment on Female Leadership. SSRN Electron. J. *2473*.

105. Murphy, M.C., Steele, C.M., and Gross, J.J. (2007). Signaling Threat. How Situational Cues Affect Women in Math, Science, and Engineering Settings. Psychol. Sci. *18*, 879–885.

106. Reuben, E., Sapienza, P., and Zingales, L. (2014). How stereotypes impair women's careers in science. Proc. Natl. Acad. Sci. U. S. A. *111*, 4403–4408.

107. Eagly, A.H., Wood, W., and Diekman, A.B. (2000). Social role theory of sex differences and

similarities: A current appraisal. Dev. Soc. Psychol. Gend. *12*, 174.

108. Lyness, K.S., and Heilman, M.E. (2006). When fit is fundamental: Performance evaluations and promotions of upper-level female and male managers. J. Appl. Psychol. *91*, 777–785.

109. Amon, M.J. (2017). Looking through the glass ceiling: A qualitative study of STEM women's career narratives. Front. Psychol. *8*, 1–10.

110. Bruckmüller, S., Ryan, M.K., Rink, F., and Haslam, S.A. (2014). Beyond the glass ceiling: The glass cliff and its lessons for organizational policy. Soc. Issues Policy Rev. *8*, 202–232.

111. Maxwell, N., Connolly, L., and Ní Laoire, C. (2019). Informality, emotion and gendered career paths: The hidden toll of maternity leave on female academics and researchers. Gender, Work Organ. *26*, 140–157.

112. Minello, A. (2020). The pandemic and the female academic. Nature, 17–19.

113. Crabb, A. (2020). Men at Work: Australia's Parenthood Trap. (Black Inc.).

114. Dattani, K. (2021). Rethinking social reproduction in the time of COVID-19. J. Aust. Polit. Econ.

115. Ceci, S.J., and Williams, W.M. (2011). Understanding current causes of women's underrepresentation in science. Proc. Natl. Acad. Sci. U. S. A. *108*, 3157–3162.

116. Gardiner, M., Tiggemann, M., Kearns, H., and Marshall, K. (2007). Show me the money! an empirical analysis of mentoring outcomes for women in academia. High. Educ. Res. Dev. *26*, 425–442.

117. Jackson, J.F.L., and O'Callaghan, E.M. (2009). What do we know about glass ceiling effects? A taxonomy and critical review to inform higher education research. Res. High. Educ. *50*, 460–482.

118. Laniran, A., and Laniran, T. (2017). Socio-cultural Career Progression Barriers for Women in Academics: A Case of the Federal College of Education (Special) Oyo, Nigeria. Asian Res. J. Arts Soc. Sci. *2*, 1–10.

119. Latimer, J., Cerise, S., Ovseiko, P. V., Rathborne, J.M., Billiards, S.S., and El-Adhami, W. (2019). Australia's strategy to achieve gender equality in STEM. Lancet *393*, 524–526.

120. Sagebiel, F. (2018). Gender and Network Awareness in / for successful leadership in academic Science and Engineering. Int. J. Gender, Sci. Technol. *10*, 25–51.

121. Dennehy, T.C., and Dasgupta, N. (2017). Female peer mentors early in college increase women's positive academic experiences and retention in engineering. Proc. Natl. Acad. Sci. U. S. A. *114*, 5964–5969.

122. Driscoll, L.G., Parkes, K.A., Tilley-Lubbs, G.A., Brill, J.M., and Pitts Bannister, V.R. (2009). Navigating the lonely sea: Peer mentoring and collaboration among aspiring women scholars. Mentor. Tutoring Partnersh. Learn. *17*, 5–21.

123. Sbrocchi, C., Pecl, G., Van Putten, I., and Roetman, P. (2022). A Citizen Science Community of Practice: Relational Patterns Contributing to Shared Practice. Citiz. Sci. Theory Pract. *7*, 3.

124. Wilson, M.N., Laufer, A.E., Howard, E.M., and Wong-Ala, J.A.T.K. (2021). Lessons From the Trenches: Students' Perspectives of Their Own Marine Transdisciplinary Education. Front. Mar. Sci. *7*.

125. Van Oosten, E.B., Buse, K., and Bilimoria, D. (2017). The leadership lab for women: Advancing and retaining women in STEM through professional development. Front. Psychol. *8*, 2138.

126. Vila-Concejo, A., Gallop, S.L., Hamylton, S.M., Esteves, L.S., Bryan, K.R., Delgado-Fernandez, I., Guisado-Pintado, E., Joshi, S., Da Silva, G.M., De Alegria-Arzaburu, A.R., et al. (2018). Steps to improve gender diversity in coastal geoscience and engineering. Palgrave Commun. *4*, 1–9.

127. Johnson, M.O., and Gandhi, M. (2015). A mentor training program improves mentoring competency for researchers working with early-career investigators from underrepresented backgrounds. Adv. Heal. Sci. Educ. *20*, 683–689.

128. Johnson, A., Huggans, M.J., Siegfried, D., and Braxton, L.T. (2016). Strategies for increasing diversity in the ocean science workforce through mentoring. Oceanography *29*, 46–54.

129. Vassallo, A., Walker, K., Georgousakis, M., and Joshi, R. (2021). Do mentoring programmes influence women's careers in the health and medical research sector? A mixed-methods evaluation of Australia's franklin women mentoring programme. BMJ Open *11*, 1–8.

130. Settles, I.H., Cortina, L.M., Stewart, A.J., and Malley, J. (2007). Voice matters: Buffering the impact of a negative climate for women in science. Psychol. Women Q. *31*, 270–281.

131. Brabazon, T., and Schulz, S. (2020). Braving the bull: women, mentoring and leadership in higher education. Gend. Educ. *32*, 873–890.

132. Ghosh, R., and Reio, T.G. (2013). Career benefits associated with mentoring for mentors: A meta-analysis. J. Vocat. Behav. *83*, 106–116.

133. Straus, S.E., Johnson, M.O., Marquez, C., and Feldman, M.D. (2013). Characteristics of successful and failed mentoring relationships: a qualitative study across two academic health centers. Acad. Med. J. Assoc. Am. Med. Coll. *88*, 82.

134. Allen, T.D., Eby, L.T., and Lentz, E. (2006). The relationship between formal mentoring

program characteristics and perceived program effectiveness. Pers. Psychol. *59*, 125–153.

135. Dworkin, T.M., Maurer, V., and Schipani, C.A. (2012). Career mentoring for women: New horizons/Expanded methods. Bus. Horiz. *55*, 363–372.

136. de Vries, J. (2011). Mentoring for Change.

137. Hansford, B.., Ehrich, L.., and Tennent, L. (2004). Mentoring in education and other professions. Educ. Adminstration Q. *40*, 518–540.

138. De Vries, J.A., and van den Brink, M. (2016). Transformative gender interventions: Linking theory and practice using the "bifocal approach." Equal. Divers. Incl. An Int. J.

139. Vasquez, R., and Pandya, A.G. (2020). Successful mentoring of women. Int. J. Women's Dermatology *6*, 61–62.

140. Armstrong, M.A., and Jovanovic, J. (2017). The intersectional matrix: Rethinking institutional change for URM women in STEM. J. Divers. High. Educ. *10*, 216–231.

141. Liu, S.-N.C., Brown, S.E. V, and Sabat, I.E. (2019). Patching the "leaky pipeline": Interventions for women of color faculty in STEM academia. Arch. Sci. Psychol. *7*, 32–39.

142. European Commission (2012). A reinforced European research area partnership for excellence and growth.

143. Cook, N.J., Grillos, T., and Andersson, K.P. (2019). Gender quotas increase the equality and effectiveness of climate policy interventions. Nat. Clim. Chang. *9*, 330–334.

144. Leibbrandt, A., Wang, L.C., and Foo, C. (2015). Gender Quotas, Competitions, and Peer Review: Experimental Evidence on the Backlash Against Women, CESifo Working Paper, No. 5526, Center for Economic Studies and ifo Institute (CESifo),.

145. Care, O., Bernstein, M., Chapman, M., Diaz Reviriego, I., Dressler, G., Felipe-Lucia, M., Friis, C., Graham, S., Haenke, H., Haider, L., et al. (2021). Creating leadership collectives for sustainability transformations. Sustain. Sci.

146. Settles, I.H., Cortina, L.M., Malley, J., and Stewart, A.J. (2006). The climate for women in academic science: The good, the bad, and the changeable. Psychol. Women Q. *30*, 47–58.

147. Handley, I.M., Brown, E.R., Moss-Racusin, C.A., and Smith, J.L. (2015). Quality of evidence revealing subtle gender biases in science is in the eye of the beholder. Proc. Natl. Acad. Sci. U. S. A. *112*, 13201–13206.

148. Windsor, L.C., and Thies, C.G. (2021). Mentorship:"Men in the Middle" and Their Role as Allies in Addressing Gender Bias. PS Polit. Sci. Polit., 1–3.

149. Madsen, S.R., Townsend, A., and Scribner, R.T. (2020). Strategies that male allies use to

advance women in the workplace. J. Men's Stud. *28*, 239–259.

150. Harding, N.A. (2020). Co-constructing feminist research: Ensuring meaningful participation while researching the experiences of criminalised women. Methodol. Innov. *13*.

151. Maynard, M. (1994). Methods, practise and epistemology: The debate about feminism and research. In Researching Women's Lives from a Feminist Perspective, M. Maynard and J. Purvis, eds. (Taylor & Francis), pp. 10–26.

152. Bryman, A. (2012). Social Research Methods 4th ed. (Oxford University Press).

153. Moon, K., and Blackman, D. (2014). A Guide to Understanding Social Science Research for Natural Scientists. Conserv. Biol. *28*, 1167–1177.

154. Crenshaw, K. (1989). Demarginalizing the intersection of race and sex: A black feminist critique of antidiscrimination doctrine, feminist theory and antiracist politics. Univ. Chic. Leg. Forum, 139–168.

155. Bowleg, L. (2012). The problem with the phrase women and minorities: Intersectionality-an important theoretical framework for public health. Am. J. Public Health *102*, 1267–1273.

156. McKinnon, M., and O'Connell, C. (2020). Perceptions of stereotypes applied to women who publicly communicate their STEM work. Humanit. Soc. Sci. Commun. *7*, 1–8.

157. Armstrong, M.A., and Jovanovic, J. (2015). Starting at the crossroads: Intersectional approaches to institutionally supporting underrepresented minority women stem faculty. J. Women Minor. Sci. Eng. *21*, 141–157.

158. Flyvbjerg, B. (2006). Five misunderstandings about case-study research. Qual. Inq. *12*, 219–245.

159. Cvitanovic, C., Wyborn, C., Glenn, E., Kelly, R., Louder, E., van Putten, E.I., and Bednarek, A. (2021). Ten considerations for research funders seeking to enhance knowledge exchange and the impact of marine science on policy and practice. Front. Mar. Sci., 1050.

160. Noy, C. (2008). Sampling knowledge: The hermeneutics of snowball sampling in qualitative research. Int. J. Soc. Res. Methodol. *11*, 327–344.

161. Norström, A. V., Cvitanovic, C., Löf, M.F., West, S., Wyborn, C., Balvanera, P., Bednarek, A.T., Bennett, E.M., Biggs, R., de Bremond, A., et al. (2020). Principles for knowledge co-production in sustainability research. Nat. Sustain. *3*, 182–190.

162. Cvitanovic, C., Shellock, R.J., Mackay, M., van Putten, E.I., Karcher, D.B., Dickey-Collas, M., and Ballesteros, M. (2021). Strategies for building and managing 'trust' to enable knowledge exchange at the interface of environmental science and policy. Environ. Sci. Policy *123*, 179–189.

163. Glaser, B., and Strauss, A. (1967). The Discovery of Grounded Theory: Strategies for Qualitative Research. (Aldine).

164. Charmaz, K. (2006). Constructing grounded theory: A practical guide through qualitative analysis. (SAGE).

165. Chun Tie, Y., Birks, M., and Francis, K. (2019). Grounded theory research: A design framework for novice researchers. SAGE Open Med. *7*, 1–8.

166. Hay, I. (2010). Qualitative research methods in human geography. (Oxford University Press Canada).

167. Sbaraini, A., Carter, S.M., Evans, R., and Blinkhorn, A. (2011). How to do a grounded theory study: A worked example of a study of dental practices. BMC Med. Res. Methodol. *11*, 128.

168. Glaser, B.G. (1978). Theoretical sensitivity: advances in the methodology of grounded theory. (Sociology Press).

169. Eade, D. (2007). Capacity building: Who builds whose capacity? Dev. Pract. *17*, 630–639.

170. Cvitanovic, C., McDonald, J., and Hobday, A.J. (2016). From science to action: Principles for undertaking environmental research that enables knowledge exchange and evidence-based decision-making. J. Environ. Manage. *183*, 864–874.

171. Jackson, K., and Bazeley, P. (2019). Qualitative Data Analysis with NVivo. 3rd ed. (SAGE).

172. Marshall, N.A., Friedel, M., van Klinken, R.D., and Grice, A.C. (2011). Considering the social dimension of invasive species: The case of buffel grass. Environ. Sci. Policy *14*, 327–338.

173. Saldaña, J. (2013). The Coding Manual for Qualitative Researchers (3rd edition) 2nd ed. (SAGE).

174. King, N., Horrocks, N., and Brooks, J. (2018). Interviews in qualitative research. 2nd ed. (SAGE Publications).

Figure titles and legends

Figure 1: The ten most frequently discussed academic and interdisciplinary challenges.

The most commonly discussed academic and interdisciplinary challenges and gendered challenges experienced by women leaders (N=34). For the purpose of this study, a ‘leader’ is defined as a researcher who holds some form of leadership role at any level within an academic institution (i.e. leading a research institution, team, project or program.

Figure 2: The ten most frequently discussed enablers of women’s leadership.

The most commonly discussed enablers of women’s leadership, including systems, processes and strategies (N=34). For the purpose of this study, a ‘leader’ is defined as a researcher who holds some

form of leadership role at any level within an academic institution (i.e. leading a research institution, team, project or program.

Tables titles and legends

Table 1: Analysis hierarchy of non-gender specific challenges to women's leadership.

The themes derived from research participants, related to the challenges that leaders experience as a result of working in academia and undertaking interdisciplinary marine research (N=34). The themes are ordered from most frequently mentioned to least frequently mentioned.

Theme	Subtheme	Frequency[a]	Number of sources[b]
Institutional	Limited institutional support and capacity	31	15
	Academic or workplace culture	21	13
	Institutional structure and policies	17	13
	Career progression and job insecurity	9	7
	Isolation and integration	8	6
	Poor leadership within institutions (e.g. from superiors)	6	4
	Lack of recognition of interdisciplinary marine research	43	17
Practical and Process	Working with researchers from other disciplines	28	13
	Complexity of interdisciplinary marine research	22	13
	Publishing	7	7
	Leading and managing staff	8	6
	Lack of leadership training	6	5
Social	Racial discrimination and prejudice	28	14
	Age discrimination	22	12
	Inequality	12	8
Financial	Lack of available and suitable funding	26	15
Individual	Demanding workload	16	10
	Gaining credibility or authority	9	6
Political	Socio-political challenges	10	6
Other	No general challenges	4	2
	Miscellaneous [c]	17	11

[a] Frequency refers to the number of times a theme was coded across all interview transcripts.
[b] The number of sources represents the number of unique interviewees (i.e. participants) who raised the theme during the interview process (maximum potential N=34).
[c] Miscellaneous topics described by participants (e.g. poor science communication and switching to online teaching).

Table 2: Analysis hierarchy of gendered challenges to women's leadership

Analysis hierarchy of themes derived from research participants related to gendered challenges to women in leadership within academic interdisciplinary marine research institutions (N=34). The themes are ordered from most frequently mentioned to least frequently mentioned.

Theme	Subtheme	Frequency[a]	Number of sources[b]
Social	Isolation and underrepresentation	51	24
	Stereotyping	41	19
	Expectations of women	41	19
	Engagement in external activities	18	12
	Power imbalance	13	8
	Lack of awareness of gender-issues	6	5
Practical and process	Parenthood and caring responsibilities	51	27
	'Glass ceiling'	22	14
	Job insecurity	8	5
	Gender pay gap	4	4
Individual	Gaining credibility	40	22
	Bullying	25	14
	Self confidence	12	7
	Acceptance of women leaders	10	8
	Sexual harassment	8	7
	Appearance	6	4
Institutional	Institutional policies and support	23	13
	Workplace and academic culture	9	8
	Hiring and evaluation	7	6
	Institutional structures	4	3
Financial	Lack of suitable funding opportunities	3	3
Other	No gender-based challenges or unable to identify them	24	13
	Miscellaneous [c]	11	7

[a] Frequency refers to the number of times a theme was coded across all interview transcripts.
[b] The number of sources represents the number of unique interviewees (i.e. participants) who raised the theme during the interview process (maximum potential N=34).
[c] Miscellaneous topics described by participants (e.g. lack of expertise in mentorship and the COVID-19 pandemic).

Table 3: Analysis hierarchy of enablers of women's leadership.

Analysis hierarchy of themes derived from research participants, related to enablers of women's leadership within academic interdisciplinary marine research institutions (N=34). The themes are ordered from most frequently mentioned to least frequently mentioned.

Theme	Subtheme	Frequency	Number of sources
Social	Support and encouragement from superiors	54	21
	Support and encouragement from peers	27	16
	Informal networking	23	14
	Formal networking	12	7
	Role models for women scientists	10	8
	Male allies	5	5
	Support and encouragement from family and friends	4	4
Practical and process	Mentoring schemes	31	14
	Increasing visibility and exposure of women scientists	14	9
	Offering leadership training and schemes	12	8
	Career planning and coaching	10	8
	Offering interdisciplinary research training	10	5
Institutional	Implementing diversity, equity and inclusion policies	21	13
	Creating a family-friendly environment	19	12
	Improving academic or workplace culture	17	13
	Raising awareness and understanding of gendered issues	12	8
	Providing women scientists with opportunities for leadership	14	9
	Increasing institutional support and capacity	12	7
	Offering flexible working	7	5
Individual	Adopting specific characteristics and /or behaviours	54	20
	Putting women scientists forward for career opportunities	16	11
	Adopting research strategies	17	12
Financial	Providing funding for women scientists	14	11
Other	Miscellaneous	10	9
	No strategies or enablers	2	1

[a] Frequency refers to the number of times a theme was coded across all interview transcripts.
[b] The number of sources represents the number of unique interviewees (i.e. participants) who raised the theme during the interview process (maximum potential N=34).
[c] Miscellaneous topics described by participants (e.g. evaluation of institutions and 360 degree reporting).