Equity at Sea
Gender and inclusivity in UK sea-going marine science

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Today, we can celebrate a strong representation of women in sea-going science in the United Kingdom, providing positive role models for early-career female marine scientists. However, women continue to face challenges to their progression in their marine science careers, especially those who are also members of other under-represented groups. In this article we consider gender equity and equality in participation and leadership in sea-going marine science in the UK, discussing successes and lessons learned for the future. After a brief history of UK women in ocean science, and a summary of some recent advances in gender equality, we look at further areas in need of improvement, and ask whether successes in improved gender equality can be transferred to tackling other forms of under-representation in sea-going science.

Women in UK sea-going marine science: the historical context

In the majority of countries undertaking marine research, women were largely excluded from sea-going expeditions until the mid-20th century, with the exception of those formidable few who dressed as men, stowed away, or controversially joined expeditions with their husbands. The exclusion of women from ships affected not only areas of science and technology, but also participation and leadership in areas such as marine governance, policy-making and sustainable development. The historical explanation was that this marginalisation was largely a result of an 'ancient taboo', which considered allowing women on ships to be bad luck – a taboo that has lasted until surprisingly recently. More recent barriers to women working in marine subjects – especially on sea-going expeditions – included perceived limitations associated with traditional family roles (including parental responsibilities), health and safety (including suitability for physically challenging activities), and what were often considered insurmountable challenges in supplying facilities and provisions for women (including separate cabins, bathrooms and supply of sanitary products). That these barriers actually existed is highly questionable – they could well have been a convenient pretext for a more complicated narrative involving discrimination.

Box 1 Under-represented groups in science

Within the Science, Technology, Engineering, Mathematics and Medicine (STEMM) disciplines, women and minority groups have faced significant challenges in gaining employment and attaining leadership roles, and so are under-represented within their chosen fields. Under-represented groups include: individuals who identify as Black, Asian or as a member of another ethnic minority group, women, and individuals who identify as lesbian, gay, bisexual, transgender, queer, intersex, asexual, or as having other gender/sexual identities (collectively referred to as LGBTQIA+), those from low-income backgrounds, and those who have a form of disability.

The influence of gender (see Box 2) in STEMM disciplines has been discussed widely, probably more so than barriers experienced by other under-represented groups. In many STEMM areas, women, and those who identify as non-binary, are still under-represented in more senior positions, and statistics show that they are also more likely than their male counterparts to lose out on earnings. Furthermore, gender-based discrimination often operates in tandem with other forms of discrimination, including unequal treatment on the basis of, for example, socioeconomic background, race, sexuality, disability and/or mobility impairment; those who belong to intersectional groups (e.g. a woman of colour, a transgender person, or a disabled woman) may be disadvantaged in multiple ways. In the geosciences, only 3.8% of tenured or tenure-track individuals in the top one hundred departments in the US are people of colour, and over the past 40 years in the US there has been no improvement in diversity within geosciences as a whole.

Box 2 Definitions of gender, gender identity, gender equality and gender equity

Our first aim here is to provide a brief history of UK women in sea-going ocean science, but we have to acknowledge that historically, gender was viewed as binary, so we have not been able to capture the situation across the full gender identity spectrum. So what are the differences between gender and gender identity, and what do we mean by gender equality and equity?

Gender and gender identity Gender is defined as an individual's sense of self, i.e. male, female, both or neither of these, and is developed socially and culturally. Gender identity can be expressed in many ways, including the way someone might dress, their name, the pronouns they use, and behaviours. Individuals can also identify as agender – this is when an individual identifies as gender neutral. If an individual identifies as transgender, this is described as having a gender identity and/or gender expression which is different from what is typically associated with the sex they were assigned (based on genitalia) at birth. Identifying as non-binary is defined as having an identity, or expressing an identity, which doesn't fit with man or woman. From Stonewall (2020), GLAAD (2020), Gender Minorities Aotearoa, New Zealand (2020)

Gender equality is the 'equal valuing by society of both the similarities and the differences between women and men and the different roles they play'. Intergovernmental Oceanographic Commission of UNESCO (2017)

Gender equity is the 'process of being fair to women and men. To ensure fairness, strategies and measures must often be available to compensate for women's historical and social disadvantages that prevent women and men from otherwise operating on a level playing field. Equity leads to equality.' United Nations Population Fund, UNFPA (2020)

Indeed, women's traditional role in the family home as 'stewards of natural and household resources' could have been considered an advantage for working in ocean governance and natural resources (e.g. fisheries). Thankfully, there are now few proponents of the idea that supplying provisions for women in a ship's bond is problematic, and few who believe that women are not capable of carrying out physically challenging roles in any occupation.

The history of sea-going women in research begins in 1766, when Jeanne Baret (1740–1807), dressed as a teenage boy, joined expeditions as assistant to the naturalist Philibert Commerçon onboard the ships *La Boudeuse* and *L'Étoile*. This French botanist became the first known sea-going woman scientist, was the first to reach Antarctic waters, and is recognised as the first woman to complete a circumnavigation of the globe. It was not until the last century, however, that women were included in leadership roles in marine science itself. Maria Klenova (1889–1976), a Soviet researcher who, in 1929, worked as a marine geologist on the RV *Perseus*, was the first woman to lead a scientific expedition.

Sea-going botanist, Jeanne Baret, disguised as a boy

The UK story of professional female marine scientists can be said to have started with Rosa Lee (1884–1976), who was the first woman to graduate in Mathematics from Bangor University and the first woman to be employed by the Marine Biological Association (MBA). Rosa was a statistician, and initially worked at the MBA's Lowestoft Laboratory.* In 1910 the staff were transferred to the Board of Agriculture and Fisheries, which 'did not employ women scientists'; following protests by the MBA, Rosa was allowed to continue her work as a civil servant. Rosa's achievements include realising that growth rings on fish scales could be used to assess changes in

Rosa Lee in a group of staff at the Marine Biological Association's Lowestoft laboratory in 1907
(Photo courtesy of Cefas)

*This later became the main lab of what is now the Centre for Environment, Fisheries and Aquaculture Science (Cefas).

fish growth rate with age. Rosa's discovery (later known as the Rosa Lee Phenomenon) was published in a 1920 issue of *Nature* and is still relevant in fisheries science today. Rosa's achievements are all the more impressive given that she was not allowed on research vessels, and her employment as a civil service scientist came to an end in 1919 simply because she married.

Marine biologist Marie Lebour (1876–1971) published a paper on molluscs in 1900, but her professional research career began in 1915 when she joined the MBA in Plymouth. Marie was well known for her work on life cycles of marine animals, notably molluscs and their parasites, and fish. She was also interested in microplankton and discovered at least 28 new species. Marie published extensively, and many of her publications are still referred to today.

In 1922, Sheina Marshall (1896–1977), an expert in copepods, was appointed to the staff of the Marine Biological Station at Millport, where she later became Deputy Director. During 1928–29 she went on an expedition to the Great Barrier Reef, led by Maurice Yonge. Uniquely for the time, this expedition involved women in active roles both on the boats and in the shore party, and Sheina had key responsibilities in both science and logistics. She received many accolades throughout her career, breaking considerable ground for a woman in science in the mid-20th century, including being one of the first women to be elected as a Fellow of the Royal Society of Edinburgh in 1949 (winning their Neill Prize in 1971), becoming a Fellow of the Royal Society in 1961, and being honoured with an OBE in 1966.

The first woman to go to sea as a scientific researcher in UK waters was Dorothy Elizabeth Thursby-Pelham (1884–1972). Dorothy worked on North Sea plaice populations from the 1930s onwards, gaining great respect in the field both nationally and internationally and becoming an active member of the International Council for the Exploration of the Sea (ICES).

Dorothy Thursby-Pelham, photographed at the Fisheries Laboratory in Lowestoft in the 1930s. (Photo courtesy of Cefas)

Sheina Marshall. This photograph is on display at the Scottish Association for Marine Science (SAMS, Oban) which evolved out of the Marine Biological Station at Millport. Text accompanying the photograph describes Sheina as 'among the founders of biological oceanography'. (By courtesy of SAMS)

Despite these pioneers, largely in the fisheries sector, in the mid 20th century there were very few women working in UK marine science – in any role. Women faced considerable obstacles to participation in UK marine science; notably, the Challenger Society only allowed women to join after the Second World War. By the 1950s, the National Institute of Oceanography (NIO) had been established in Wormley, but less than a fifth of the scientists who worked there were women, and they represented a much smaller proportion of the sea-going staff. The vast majority of female staff were researchers in computer science and mathematics; they developed a number of key theoretical ideas, but very few carried out observational or sea-going research.

No women were allowed to sail on the RRS *Discovery II*, and it wasn't until 1963 that marine microbiologist Betty Kirtley sailed on the first *Discovery III* cruise, becoming the first woman from the NIO to sail on an expedition. This notable event was described as 'breaking new ground' by Anthony Laughton (Director at Wormley, 1978–1988) in an interview with the British Library in 2010. Three years after Betty Kirtley worked at sea, Carol Williams, from the Department of Geodesy and Geophysics at Cambridge University's Madingley Rise site, became the first woman to go to sea as a geophysicist. Carol went on to have a long career in Cambridge and as an international scientific leader, including having a coordinating role on the scientific committee of the Deep Sea Drilling Project.

Women also went to sea on NIO cruises in the 1960s in technical and computational roles. In Scotland, the Fisheries Research Services (FRS; now Marine Scotland Science) tried to involve more female scientists in its cruises in the late 1960s and early '70s but FRS's *Explorer* and *Scotia 2*, and their smaller vessels, were perceived to lack suitable accommodation/provisions as they only had shared facilities. *Scotia 3*, launched in 1971, finally had one *en suite* cabin for potential female scientists.

In the mid 1950s, marine biologist Eve Southward began to investigate benthic fauna in the Bay of Biscay, in collaboration with her husband Alan Southward, who was on the staff of the MBA at Plymouth. This work involved a long series of cruises on RVs *Sarsia* and *Frederick Russell;* Eve also worked on RVs *Sonne*, *Challenger* and *Shackleton*. In the 1970s, she was invited to join US cruises to the newly discovered hydrothermal vent sites in the Pacific, on RV *Atlantis*; she also went down in the submersible *Alvin*. Despite being highly respected for her expertise, Eve remained an unpaid independent researcher; she was often accompanied by female assistants.

Eve Southward sorting mud on RV Sarsia, *in the Bay of Biscay in 1974 (Photo: Alan Southward)*

Denise Smythe-Wright was, we believe, in 1975 aboard the RRS *Shackleton*, the first woman scientist in the UK to go to sea as a Ph.D student. She was required to take a final-year female undergraduate with her as a companion, and they had to use the Captain's bathroom as there was no other provision. Denise was also – to the best of our knowledge – the first UK oceanographic mother-at-sea having given birth to her son three months before a five-week expedition to the North Atlantic in August 1991; she was nicknamed 'Mum' by the crew. Aenea Reid from Scotland's FRS's gear section was the first woman to lead a cruise onboard FRS *Explorer* in the 1970s, despite there being no adequate facilities on board.

Opportunities for women at sea began to gradually change in the UK during 1979–1980, when the Institute of Oceanographic Sciences (IOS, previously the NIO) hired thirteen new staff to work on radioactive waste in the oceans. Four of the new scientists were women: three chemists (including Denise Smythe-Wright and Sarah Colley) and a geophysicist. Sarah Colley went on to be a PSO (Principal Scientific Officer) on ships in the 1980s, and in 1988 Penny Barton was the first female PSO of *Discovery III*. Denise was the only woman on a committee that was responsible for the banning of radioactive waste dumping at sea in 1985, and was the Scientific Secretary to the International Scientific Steering Committee of the World Ocean Circulation Experiment (WOCE) for five years in the 1980s and subsequently the UK WOCE Project Manager.

There was also a greater representation of women in active support roles at sea. From the 1970s there were a number of women who regularly supported cruises as computer scientists for typically three to four months each year on the UK research vessels and charter vessels (RRS *Discovery*, RRS *Shackleton*, RRS *Challenger*, MV *Starella*, MV *Farnella* plus others). These women included Ruth Sherwood (*née* Howarth), Theresa Cooper (*née* Colvin), Doriel Jones, Daphne Heathershaw and Kay Batten (*née* Potter) *(see below)*. Initially, their involvement was via IOS Wormley,

Sea-going women computer scientists from the RVS Shipborne Computer Group

Left *Doriel Jones and Kay Batten on board RRS* Charles Darwin *in February 1985 on their way into Falmouth following instrument trials prior to the vessel's first scientific cruise. Others in the photo are (from left to right) John Sherwood, Martin Beney and Chris Jackson. (Photo: Ted Lawson)*

Below *Theresa Cooper (*née *Colvin), RVS Shipborne Computer Group, c.1980 alongside the S1 PDP11/34 System in Barry; the system was portable and first installed in the on-board clean room during the RRS* Discovery *cruise D94. (Photo: Edward Cooper)*

The RRS* Discovery *CTD rosette then and now
Left Discovery III *cruise D200 in 1993. (Photo: John Gould)*
Right Discovery IV *cruise DY078 in 2017. (Photo: Penny Holliday)*

before they were transferred to the IOS (then RVS, Research Vessel Services) Shipborne Computer Group at Barry. All were at least degree qualified. Daphne Heathershaw sailed on RRS *Discovery* in 1974 whilst a postgraduate at Bangor (University College North Wales) prior to joining IOS Barry. Doriel worked on UK- and US-based cruises for over twenty years, including on the RRS *Discovery* in 1984, with physical oceanographer Karen Heywood and a female radio officer, and on the HMS *Farnella* in 1985, with US Geological Survey scientist Kathy Scanlon.

By the 1990s, the cohort of physical and chemical oceanographers at IOS (now IOS Deacon Laboratory, IOSDL) expanded for UK WOCE, which included a significant number of cruises. Both men and women from IOSDL, and its Southampton-based James Rennell Centre, were encouraged to go to sea once a year, whatever their position in the organisations. At the time, there were a number of women employed – mainly in junior grades – as James Rennell Centre science and technical staff. These cruises, in addition to expeditions led by UK universities (notably Bangor University), presented sea-going opportunities for the growing number of oceanography Ph.D students and post-docs from the UK and overseas.

Support for women scientists at sea was, however, often lacking. Even basic amenities such as waste disposal bins for sanitary products were not always provided, and some younger women were told by older women to throw them over the side, secretly, at night. Furthermore, the culture on board could be very confrontational and challenging, perhaps even more so than in the 1970s and '80s. Women also described persistent unwanted attention, sexual harassment, and bullying; with no guidelines about behavioural standards, and no reporting procedures in place, women (and indeed anyone who was targeted) were effectively unprotected. On the more positive side, WOCE highlighted some excellent role models active in observational oceanography – senior women who were leading cruises and producing outstanding research – particularly in the US, but also including Denise Smythe-Wright and Karen Heywood in the UK. In 2005, after several years of expeditions at sea, as well as involvement in WOCE, Karen became the first female Professor of Physical Oceanography in the UK. In 1990, Carol Pudsey was the first PSO on an Antarctic cruise; many cruises later in 2003 she was awarded the Polar Medal for services to Antarctic science. In Scotland more female scientists joined cruises on the converted MV *Clupea*, MRV *Alba-Na-Mara* and MRV *Scotia* 4, including sporadically as PSOs on those vessels and charters (from the 2000s).

The Valkyries – sometimes known as the Physics Team – during a cruise led by Margaret Yelland on the RRS James Clark Ross *in December 2011. All bar the engineer, Robin, were women – a far cry from Margaret's first cruise in 1989 when she was the only woman on the ship. From left to right: Helen Snaith, Vikki Frith, Robin Pascal, Sarah Norris (now Sarah Dennis), Mairi Fenton, Margaret Yelland and Penny Holliday.*

Women working in UK institutions have been (and are largely still) under-represented in leadership positions within Higher Education Institutes and national organisations, and on scientific steering committees of international marine programmes. It wasn't until 2009, when Lisa McNeill co-led Expedition 319 to the Nankai Margin, south-west Japan, that there was a woman Co-PSO from a UK institution in the Integrated Ocean Drilling Program (IODP). Lisa also went on to be the first person to be a Co-PSO on all three International Ocean Discovery Program (IODP) drilling platforms in 2017. Other international organisations have also only recently promoted women to leading positions. Denise Smythe-Wright was elected as President of IAPSO* (2015–2019), sat on the SCOR† executive, and is now the International Union of Geodesy and Geophysics (IUGG) liaison officer to the International Oceanographic Commission of UNESCO. Carol Robinson was elected Chair of the Integrated Marine Biosphere Research project (IMBeR) in 2016.

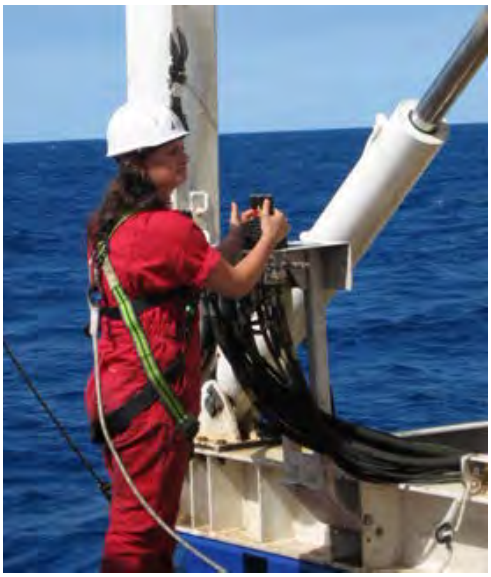
Carol was also the first female President of the Challenger Society (2008–2010); since then, the Society has had two further female Presidents (Hilary Kennedy, 2012–2014, and Rachel Mills, 2016–2018), with Ros Rickaby taking on the role for 2020–2022. There has however been severe under-representation in recognition and awards, especially for senior female scientists (e.g. celebratory conferences or 'lifetime achievement' awards).

*IAPSO is the International Association for the Physical Sciences of the Oceans, which is part of the IUGG.

†SCOR is the Scientific Committee on Oceanic Research. IMBeR is one of SCOR's Large Scale Ocean Research Projects.

Present-day situation and recent successes

Gender balance in UK marine science has improved greatly in recent years, and there has been a growing appreciation of the benefits of gender diversity in field-based research. Advances and achievements have also come in marine governance and science policy, in addition to leadership roles in technical and ship's crew positions. To illustrate this progress we present a few case studies; we cannot use aggregated information on cruise participation by gender, as data on self-verified gender identity, acknowledging the full gender spectrum, are not available.



Marine technician Ella Richards, here shown during an RRS James Cook *cruise in 2015. (Photo: Veerle Huvenne)*

Sue Hartman and Hannelore Theetaert (Flanders Marine Institute, VLIZ) during the June 2019 RRS Discovery *cruise to exchange the moorings and instrumentation on the PAP-SO buoys (one can seen close up on the left). (Photo: Jon Campbell)*

In summer 2017, for the first time the three main UK research vessels had concurrent expeditions led by female PSOs: the RRS *James Clark Ross* was in the Barents Sea as part of the UK NERC Changing Arctic Ocean programme (PSO Joanne Hopkins); the RRS *Discovery* IV was in the Iceland Basin and in the vicinity of Rockall, traversing the NERC Extended Ellett Line and servicing UK OSNAP moorings (*p.23, above right*) (PSO Penny Holliday, Captain Jo Cox); and later in the Labrador Sea as part of the EU-funded ICY-LAB project (PSO Katharine Hendry, Captain Jo Cox, and two female technicians, including Ella Richards (*above)*); and the RRS *James Cook* was in the tropical Atlantic as part of the NERC-funded ZIPLOC project (PSO Claire Mahaffey).

Expeditions serving longer time-series studies are useful for assessing improvements in gender equality through time. For example, the Porcupine Abyssal Plain Sustained Observatory (PAP-SO) cruise programme has been running since 1985. Previous PAP expeditions have had a good representation of women, including crew. However, to date there have been very few women PSOs on the PAP programme. Sarah Colley was the first woman to lead a PAP expedition, in 1991 on board the RRS *Charles Darwin*. Most recently, Sue Hartman from the National Oceanography Centre (NOC) was PSO in 2019 (*left*), and Jennifer Durden was due to take the position in 2020 (the cruise was cancelled because of the Covid-19 crisis).

Women have been less represented in scientific leadership in the Atlantic Meridional Transect (AMT) programme, with only one woman PSO (Carol Robinson) in 2003; whilst there is good representation of women in the AMT programme, the majority of these scientists have been early-career researchers. Long-term observations of the hydrography in the Faroe–Shetland Channel have been conducted by Marine Scotland Science (and predecessors) since the late 19th century, with the first female PSO (Berit Rabe) in 2014, onboard MRV *Scotia*; since then, at least one out of three Marine Science Scotland's regular cruises in the Faroe–Shetland Channel has been conducted by a female PSO.

When using such time-series programmes as case studies of progress in gender equality in leadership roles it is important to bear in mind that they are often institution-based, and so there may be various reasons behind PSO designation (e.g. a small 'pool' of available researchers, or established PSOs who hold their positions until retirement, etc.). Larger international programmes – which are becoming increasingly important for addressing broad ocean–climate interactions – provide further insight into the leadership roles played by UK women in marine science. For example, the Overturning in the Subpolar North Atlantic Programme (OSNAP) is a large (£50M) and successful international observations-based research project that has UK women in strong leadership positions, including PSOs Penny Holliday and Helen Johnson. Similarly, IODP expeditions on the RV *JOIDES Resolution* have become more balanced in terms of participant gender.

In addition to leading scientific research, women scientists in marine science are also keen innovators: for example, in recent years they have been the driving force behind the use of some of the latest robotic technology for marine observations, including the use of *Autosub Long Range*, ocean gliders and remotely operated vehicles (ROVs). Since 2013, most of the expeditions using the National Marine Facility ROV *Isis* were coordinated by women, and in 2015 Veerle Huvenne was the first PSO to use three different robotic vehicles (*Autosub6000*, the ROV *Isis* and a Seaglider) in a simultaneous, combined operation during an expedition on the RRS *James Cook*.

As well as gender equality amongst scientists and technicians, there is also the question of gender equality for other essential roles at sea, which – again – cannot be assessed without the collection of relevant data on participation. However, there are some examples of continued improvement in gender balance, including the appointment of Alexis Lee as the first female Officer in Charge of a Marine Scotland Compliance expedition – an acheivement that was celebrated in a blog for Merchant Navy Day in 2019.

What has driven these successes?

Many of the women who now occupy leadership positions in UK institutions were trained in the period 1980–2000: the era of significant growth in the UK science base when there was a significant rise in the number of individuals studying for Ph.Ds. With this growth came a new generation of Ph.D supervisors who recognised that talent and hard work are found across all parts of society. Pioneers in this area included key members of the Challenger Society community such as Paul Tyler, Harry Elderfield, Peter Liss and Tim Jickells, who supervised many female Ph.D students who went on to hold positions in leading institutes and universities, supervising their own students and researchers. This combination of mentorship, championing of new talent and providing opportunity for interaction with the wider science community was a key driver of this change.

Assessments of gender diversity in marine science have focussed on the importance of two aspects: improved mentoring schemes and consistently supportive work environments.

Mentoring Mentoring is critical during all stages of a researcher's life, and is key to retaining under-represented groups in STEMM. An example from the marine sciences is the US-based Mentoring Physical Oceanography Women to Increase Retention (MPOWIR) organisation, which since 2007 has funded mentoring activities for women in their early career stages (postgraduate research and onwards). A survey of MPOWIR participants revealed that the scheme has had a positive impact on retention of early-career female researchers in the field, with 80% of participants with Ph.Ds completed prior to 2012 being employed in 'university/government/nonprofit research positions'. A few of the scientists who benefited from this mentoring scheme are now working in the UK and have led UK-based research expeditions. UK researcher Heather Ford (Lecturer at Queen Mary University of London and NERC Independent Research Fellow) together with Jennifer Hertzberg (postdoctoral researcher at Old Dominion University in the US) established the AGU Paleoceanography/Paleoclimatology Section mentoring scheme in December 2018. This scheme showed that participant feedback is a useful means for assessing success of mentoring schemes and identifying pathways for improvement.

The above examples of mentoring programmes all take place on land, but there are also valuable opportunities for mentoring at sea. For example, Marine Scotland Science have a pioneering new scheme for training PSOs, involving appointing a Co-PSO for each expedition. Whilst this programme is open to everyone, there was an expedition in 2019 on the MRV *Scotia* where

the PSO and Co-PSO, Berit Rabe and Helen Smith, were both women (*photo below*).

Berit Rabe (right) and Helen Smith (PSO and Co-PSO, respectively) along with Matthew Gray, during a 2019 Scotia *cruise. (Photo: Matthew Gray)*

Improved work environments Work environments have been improved through flexible schemes for carers, more high visibility roles for women (including those belonging to other under-represented groups), emphasis on collaboration rather than competition, and the perception of reduced gender bias and overt sexism.

There have been a number of specific schemes and scholarships to promote women and other under-represented groups in marine science within the EU and US. In the UK, the most prominent scheme for improving the workplace environment for women is the Athena SWAN Charter, launched in 2005. This aims to promote and advance the careers of women across all STEMM disciplines. One example of a positive policy change, which arose from an Athena SWAN award submission by Marine Scotland Science, is the creation of a gender-balanced pool of trained PSOs, an action endorsed by its Board in July 2020. However, actions that have been implemented as a result of Athena SWAN accreditation (such as mentoring programmes) are generally limited to within institutions or informal arrangements, and nation-wide (or UK-led international) schemes for particular areas of marine science are still few and far between.

Networking Assistance with networking can also help women, and other under-represented groups, make connections and build collaborations. One good example of this, albeit from a broader subject base, is the Earth Science Women's Network (ESWN), a non-profit international organisation that started from informal beginnings in 2002 and is sponsored in part by the University of East Anglia. In addition to providing networking support for women in the geosciences, members of the ESWN leadership board have also been instrumental in securing funding for projects aimed at improving the work environment for women.

The Challenger Society now has a Diversity in Marine Science (DiMS) network which aims to improve networking for under-represented groups, and address other problems they might face. A DiMS event was held at the Challenger 2016 Conference in Liverpool, and another, for early-career researchers, was organised (with the UK Polar Network) at the Challenger 2018 Conference in Newcastle; this covered diversity at sea/in the field, alternative career paths, unconscious bias, mental health in academia, and digital media.

Continuing challenges for under-represented groups in sea-going research

A good cruise can help a scientist embrace a career in sea-going marine science, but a bad experience for themselves or a friend or colleague could make someone change their career plans, and this does happen. This problem disproportionately affects under-represented groups, given that they are more likely to be targeted by harassment or unwanted attention. Unacceptable behaviour is likely to impact those in early-career stages more strongly, but it is experienced by under-represented groups at all career stages.

PSOs generally receive little or no training in how to support team members who feel they are being unfairly treated, although videos covering harassment are now mandatory at the beginning of expeditions on the main NERC research vessels. The burden of tackling unacceptable behaviour often still lies with the victim. It can be extremely difficult to find the courage to report unacceptable behaviour at sea if the culture and expectations of behaviour standards are not explicitly set out by those in charge. A consistent change in culture to prevent such behaviour is needed.

There are still shortcomings in the availability of health and safety provision specific to women. Many ships are still stocked with personal protective equipment (PPE) that is not suitable or sufficient for use by the women on board: a potentially dangerous example of equipment etc. being designed with the average man – not woman – in mind (as written about recently in *Invisible Women: Exposing data bias in a world designed for men* by Caroline Criado Perez). For example, safety or survival suits are often provided predominantly in larger sizes that are both cumbersome and dangerous for smaller people, who are disproportionately, though not exclusively, women.

Menstruation at sea is still often a taboo subject. It was not until the 1990s that the issue of sanitary bins on research ships was raised. When the RRS *Discovery* was revamped in 1991, the ship was fitted with an incinerator and women were asked to put used sanitary products directly in bins ready for burning as it was not fair to ask the stewards to empty cabin bins. Provision of sanitary bins in the shared toilets on ships has been an ongoing battle, and women have had to raise the matter at cruise planning meetings, or request crew members to buy bins in port before agreeing to sail. Paper bags were sometimes provided, but were often not fit for purpose, especially for anyone experiencing heavy

periods. The situation has mostly improved in the last two years or so, with the introduction of small, sealable bags and appropriate bins in both cabins and toilets in public areas.

The increased participation of women in sea-going research has not led to equality in leadership positions. This may be a result of the lack of women in other high profile roles, the fact that (as mentioned earlier) the appointment of PSOs often lacks open and fair access to training, and because there are few opportunities for women to engage with the early planning stages of a cruise: if women are not involved from the start, it is unlikely that they will be able to take a leadership role in the final expedition. Furthermore, there may be a reluctance for women to propose sea-going research because of the long time-scales involved in the planning processes (it can take many years from the initial proposal to completion of a scientific expedition). Being away for weeks at a time is still challenging for many women due to caring commitments and other personal circumstances; women might decide to leave oceanography if they feel that caring duties and career progression do not go together.

Improved attitudes towards, and accommodation of, women at sea are probably a result of the gradually increasing number of women on ships, rather than the other way around, and there is still a stark imbalance among technicians and crew. Our research has revealed that there have been very few 'top-down' schemes that were designed to support women in sea-going marine sciences within the UK. For example, there are no UK-wide mentoring or networking schemes specifically for female marine scientists. Success has largely been driven at the level of institutions, or by individuals – often, but not only, by women, including scientists, crew and technicians. These individuals have been instrumental in driving forward informal mentoring schemes, being role models at different career stages, and repeatedly raising concerns about conditions at sea (harassment, PPE, sanitary provision etc.) until they are successful in forcing change.

How can we extend successes in gender equality to other under-represented groups?

In addition to improving inclusivity, bringing in the views of women and other under-represented individuals results in better collaboration and greater scientific impact. Can we, on a national and international level, transfer the mechanisms of success in improving gender balance in marine science to tackling other forms of under-representation?

Whilst there have been improvements in gender equality, women working in science still face discrimination and inequality, especially if they also belong to another under-represented group, even one protected by equal rights law (e.g. relating to ethnicity or disability). There is a plethora of evidence to suggest that under-represented groups face more discrimination and harassment in their workplaces, fewer opportunities to speak at conferences, have fewer collaboration and leadership opportunities, and will be less likely to apply for promotion. They might also face hostile attitudes if they speak up about these issues. Although numbers for UK marine science have not been published, anecdotally more women, individuals identifying as Black, Asian or as a member of another ethnic minority group and/or as LGBTQIA+ and/or with disabilities, are participating in sea-going research during early career stages, but are still under-represented.

Critically, under-represented groups do not see individuals with whom they identify in leadership roles. For many years, NOC Southampton proudly displayed on the wall outside the National Oceanographic Library an array of male, white leaders whose legacy was the UK oceanography discipline. These images were moved this year to a more fitting range of locations, where of course the important contributions of these pioneers of science will be recognised individually and with appropriate respect. However, it is clearly now time to enhance the diversity of those celebrated and on display, and to raise the profile of under-represented groups within ocean sciences, not only to inspire the next generation of marine scientists, but also to retain those currently in the field. Here are a few key recommendations for making it happen.

1. Introduction of UK-based schemes for under-represented groups in marine science

The establishment of funded nationwide schemes that target under-represented groups in marine science, specifically sea-going science, would drive increased availability of opportunities through 'top-down' schemes, as well as peer-to-peer engagement. Schemes such as MPOWIR and STEMSEAS (a US initiative aimed at facilitating undergraduates from diverse backgrounds taking part in short marine expeditions) could act as templates for such ventures, by providing support and opportunities for sea-going experience and mentoring. However, such schemes don't support some of the earlier career stages, so need to be expanded to encompass all career levels. The point at which undergraduate, Masters and Ph.D students are recruited is critical, especially for people from under-represented groups who could otherwise miss out on opportunities. Scholarships or fellowships could be designed specifically to support these very-early-career researchers.

The Climate Linked Atlantic Sector Science (CLASS) programme already provides opportunities for early-career researchers from all backgrounds to take part in sea-going expeditions and learn new skill sets (see pp.4–6). However, salary and some other costs are not provided, and this could present a barrier to those who already face more hurdles in acquiring funding than their white male peers. Such programmes could be extended to

encourage participation from women and other under-represented groups, and to build in specific skills, and be supported by ring-fenced funding (such as exists within the STEMSEAS programme). Waiting for equality to trickle up to marine science leadership roles will take too long, and more affirmative action at high levels is needed to stimulate diversity initiatives. Within the UK, there are schemes at Marine Scotland Science and the National Oceanography Centre to partner early-career researchers with senior staff, who could help them 'learn the ropes' and gain the experience they need to write their own research proposals and apply for cruises. Mentoring and networking schemes that bring together participants from academia, funding agencies and other stakeholders would be greatly beneficial and could go some way to help improve the diversity of successful grant holders.

2. Visibility of role models

One factor that has been shown to be greatly beneficial for widening participation is the visibility of role models from under-represented groups. We all need to tell more stories celebrating marine scientists, technicians and crew who have had achievements in the field of sea-going science, despite facing barriers, real and perceived, as a result of their backgrounds. However, greater improvements in this area can come from deliberate policies within individual groups and organisations, such as taking decisions to name awards, or rooms, or buildings after women or representatives of minorities. The Centre for Environment, Fisheries and Aquaculture Science (Cefas) and the Scottish Association for Marine Science (SAMS) both took steps in the right direction by naming a room and a teaching building after Rosa Lee and Sheina Marshall respectively. The majority of major awards in marine sciences are named after men, although a notable exception is the Challenger Society's biennial meeting poster prize, which is named after oceanographer Cath Allen.

Another new initiative, led by Rehemat Bhatia and the Micropalaeontological Society, is promoting under-represented groups through new awards, and through naming existing unnamed society awards after micropalaeontologists from under-represented groups. The AGU Earth and Planetary Surface Processes committee also recently (May 2020) announced the Marguerite T. Williams Award, named after the first Black person in the US to be awarded a geology Ph.D. Further deliberate policies could be introduced – and promoted via targeted and open advertising – to enhance diversity. For example, the Challenger Society has a goal to alternate the position of President between men and women. Conference organisers could promote visibility of under-represented groups – especially those in their earlier career stages – as session chairs and keynote speakers, using inclusive activities of the European Geosciences Union as exemplars.

Increasing the visibility of women and under-represented groups at sea is key: funding agencies, research organisations, charities and universities need to ensure diversity in the images on their websites, and in promotional or teaching materials. Care also needs to be taken to combat unconscious bias in terms of the written or spoken language used to describe science leads in these websites and documents. For example, cruise or programme websites should ensure that women and other under-represented groups are given prominent positions, and described using the same words and terminology as their male colleagues. Depiction of minority groups in marine science in the media needs to be improved in all spheres, from inclusion in news and documentary interviews to representation in fiction.

3. Better training for sea-going scientists

There are clear benefits in improving and broadening training for participants in sea-going science at all career levels – PSOs, scientists, technicians and crew. Barriers that hinder under-represented groups must be recognised in the first instance, in order to be broken down. Researchers and funders (especially those with senior oversight of cruise activities) need to be fully aware of challenges faced on board cruises, and build and implement necessary protocols and codes of conduct. Training for all participants in mental health, avoiding unconscious bias and bystander behaviour should be essential – rather than recommended – additions to pre-cruise preparation. This training, which is the responsibility of research institutes, funding agencies and universities, will help sea-going researchers understand how to manage the expectations of other participants and colleagues, and help improve the experience of everyone on board.

4. An inclusive environment on ships

Every expedition needs to have an inclusive environment that is comfortable for everyone, which can be achieved by the reasonable accommodation of requirements, in addition to suitable training in diversity issues. Provision of health and safety equipment that reflects the range of people on board should be standard. Although there are financial and logistical implications, shorter expeditions (e.g. 2 x three weeks rather than six weeks) and provision of additional expenses (e.g. for extra child-care provisions) could facilitate involvement by those with caring responsibilities which, for a range of socioeconomic reasons, disproportionately includes under-represented groups. A well advertised, easy-to-access system for supporting additional caring costs that arise when people are away at sea would make a big difference. Cruises could also be made more inclusive through schemes that allow more flexible approaches, such as the schemes to split tasks between a PSO and Co-PSO, currently being implemented by Marine Scotland Science.

The way forward

We urgently need to diversify our discipline through proactive mentorship, and by promoting and implementing positive change. Leading UK organisations, such as the Challenger Society for Marine Science, should show the way by implementing actions that will make a genuine difference, converting our ideas into a practical reality. The following proposals can be summarised as a call for a strong vision for equality and diversity in marine science, led by the membership of the Challenger Society. In developing each of these ideas we need to consider which initiatives that have helped women might also be effective in supporting other under-represented groups, and for which groups, and under what circumstances, the approaches might need to be different.

We should:

- Lead initiatives (websites, award-naming, guest seminars etc.) to increase visibility of past and present under-represented groups in sea-going marine science, for example: women, people identifying as Black, Asian or as from another ethnic minority, people identifying as LGBTQIA+, and people identifying as having a disability.
- Champion and ensure diversity in the Challenger Society (e.g. in the composition of Council, and with respect to those who receive awards) as well as in UK oceanography in general (e.g. in academic appointments, acceptance of Ph.D candidates, and during promotion processes).
- Fund and promote bursaries for under-represented groups to go to sea, particularly in leadership positions.
- Ensure that articles in Challenger Society publications are authored by – and feature – a diverse range of individuals.
- Lobby to encourage the community to take up opportunities to appoint a Co-PSO for every cruise, where either PSO or Co-PSO is an early or mid-career researcher, and to monitor and record the diversity of people in those positions, and their career progression in the longer term. This procedure has recently started on Marine Scotland Science cruises with very positive feedback.
- Lobby for NERC to provide resources for extra childcare and other additional costs incurred by sea-going staff.
- Lobby for the adequate provision of PPE for sea-going women.
- Lobby for the collection and analysis of diversity and inclusivity data for all sea-going scientists, technicians and crew.
- Refocus the Society's Diversity in Marine Science (DiMS) initiative to form a Special Interest Group that includes scientists at all career levels. This group could formulate an effective training programme suitable for all, identify existing and new resources and formalise the Society's commitment to accelerating progress towards equity.
- Create a Society award to recognise those working towards improving diversity in UK marine science.

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Further Reading overleaf ➢

Heading in the right direction! A happy group of researchers in coastal waters off Greenland in 2018 – the team is predominantly female and has representatives from a wide variety of backgrounds and four different countries. (Photo: Ellen Pedersen)

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