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Inclusive Science for a changing ocean: gender equity in elasmobranch research

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Persistent inequities in marine science continue to shape who leads research, whose work is most visible, and which questions are prioritised. In elasmobranch science, a field often defined by intensive fieldwork and long-standing cultural norms, these dynamics have direct consequences for scientific capacity and conservation outcomes. Drawing on a decade of global publication data alongside existing scholarship, this Perspective evaluates how gender representation has changed within elasmobranch research and where structural barriers remain. Authorship patterns across more than twelve thousand peer reviewed publications indicate meaningful gains in participation by women, particularly at early career stages and in lead authorship. Progression into sustained senior authorship position remains uneven, reflecting institutional and cultural constraints rather than lack of expertise. These patterns align with broader evidence of leaky career pathways that continue to privilege narrow models of authority. Rather than framing equity as a matter of representation alone, we argue that inclusion is fundamental to the intellectual robustness of elasmobranch science. Diverse leadership expands the scope of inquiry, strengthens collaboration, and improves conservation relevance. As pressures on shark and ray populations intensify, retaining and empowering diverse scientific talent is not optional. It is essential. We call for coordinated structural reform across institutions, funding systems, publishing practices, and field operations to ensure that elasmobranch science reflects the diversity of expertise required to meet accelerating ocean challenges.

KEYWORDS
diversity in marine science, gender diversity, inclusive science, research culture, shark science

1 Equity and leadership in a field under pressure

The global ocean is undergoing a period of rapid and unprecedented change (1, 2). As some of the most iconic yet threatened taxa, elasmobranchs are at the centre of this transformation (3). The convergence of climate change, accelerating biodiversity loss, and shifting governance structures demands more urgent, inclusive, and interdisciplinary marine science (4, 5). As the field evolves to meet these challenges, its internal culture must also undergo a significant transition. Despite notable progress, the systemic under-representation of women and other marginalised groups in marine science remains a persistent barrier to equitable participation and scientific impact (6–8).

The disparity in this field is well documented. While women comprise approximately 38% of the ocean science workforce (9), they hold only 28% of senior research positions, with even lower representation in technical and leadership roles (8). Globally, just 30% of researchers are women (10). This imbalance extends beyond questions of equity and has direct implications for the scope and depth of scientific inquiry (11). Syntheses from marine oceanography indicate that although women now earn an increasing proportion of doctoral degrees, they remain systematically underrepresented in funded research, invited presentations, and leadership positions across ocean science disciplines (7). Gender diversity is essential for enhancing research outcomes and fostering innovation as it incorporates a broader range of perspectives and creates more robust theoretical frameworks (12).

2 Progress in elasmobranch research: a dynamic and urgent field

Elasmobranch science is advancing rapidly. From telemetry and population genomics to conservation physiology and applied policy research, the field is diversifying in both scope and impact (13). These advances are increasingly the product of collaborative, interdisciplinary approaches that extend beyond traditional academic silos (5). Notably, there is a steady rise in female first authorship in coral reef science over the past 30 years, with growing representation in leadership and mentorship roles (14). We can observe a notable increase over years of the proportion of abstracts submitted with female first author in elasmobranch conferences (15). Moreover, for the 2025–2029 quadrennium, the IUCN Shark Specialist Group's core leadership includes 13 women and 8 men across key coordination and leadership roles (16). These trends signal a promising shift: as the discipline diversifies, so too do the questions being asked, the ecosystems being prioritised, and the outcomes being achieved. However, it is important to note that increased visibility does not necessarily translate into structural power within the discipline.

3 Breaking barriers: representation and inclusion in elasmobranch science

Persistent gender inequities continue to shape access to leadership, funding, fieldwork, and authorship across the marine sciences. Patterns documented in elasmobranch research mirror those observed more broadly, with senior authorship and project leadership disproportionately concentrated among men, limiting progression for women and other marginalised groups (6). These imbalances are reinforced by the well described leaky pipeline, whereby representation declines at successive career stages as cumulative structural biases in citation practices and peer review constrain visibility, recognition, and advancement (17).

A significant yet often overlooked barrier to equity in science is the persistence of homosocial reproduction. This phenomenon occurs when leaders, historically men, subconsciously or intentionally recruit and promote individuals who mirror their own identities and social behaviours (18). Empirical evidence supports the role of such dynamics in shaping collaboration patterns, with studies demonstrating that gender homophily can contribute to persistent disparities in authorship and publication outcomes (19). In shark science this issue is exacerbated by the historical framing of the field as a rugged, male-dominated pursuit. Shark science has often rewarded a specific brand of masculinity, creating an environment where field competency is occasionally viewed through a lens of bravado rather than purely scientific rigour (20). This dynamic manifests most clearly in the field, where professional bonds are forged in exclusive settings or high-adrenaline environments, and women are often systematically, if subtly, excluded. A similar trend was observed in shark TV programming with women representing only 20.1% of shark and ray experts featuring on Shark Week TV shows (21). Episodes including at least one female host or expert accounted for 29.8% of the total, while 5.4% featured more than one female host or expert.

Furthermore, the intersection of gender with other identities, such as nationality, language, and socioeconomic background, often compounds these barriers, particularly for researchers from the Global South facing structural constraints related to funding access and publication visibility (22). Even where formal gender policies exist, their effectiveness hinges on how they are implemented at the local and institutional levels. Research from Kenya, for example, illustrates that participatory, locally informed approaches are essential to translating top-down policy into tangible progress for female researchers (23).

4 Methods

4.1 Dataset retrieval

We quantified female representation in authorship across elasmobranch-related peer-reviewed literature published between 2016 and 2025. Publication records were retrieved from Web of Science (Clarivate Analytics) using the following Topic Search (TS) field tag, designed to capture all shark and broader elasmobranch research outputs:

TS = (shark* OR elasmobranch* OR chondrich* OR batoid*)

Search results were restricted to document types classified as research articles or review articles, yielding 12,642 publications across the ten-year period from 1 January 2016 to 31 December 2025. This timeframe was selected to provide a contemporary snapshot of authorship patterns in elasmobranch science rather than to assess long-term career trajectories.

4.2 Author extraction and harmonisation

All publication records were exported from Web of Science in.xls batches and merged into a single dataset using Python (v3.9) and the pandas library. For each publication, the full list of authors was parsed to extract (1) the first author and (2) the last or senior author. Names were standardised by splitting at the comma

delimiter (surname, given name(s)), removing trailing punctuation, and trimming whitespace. Given names were further reduced to the first token (e.g., "Maria V." to "Maria"), allowing consistent mapping to the gender-assignment procedure described below.

Where the same author's name appeared across multiple publications, harmonised naming was used to ensure consistent gender assignment across occurrences where possible, while retaining ambiguous cases as indeterminate (X).

To improve confidence in author-name harmonisation and reduce ambiguity in author identification, we conducted a secondary validation step using Web of Science ResearcherID profiles where available. These profiles represented only a small subset of authors within the broader publication corpus and were used solely to support name consistency checks rather than to define the analytical dataset or assign gender directly. Within this validation subset, 201 unique researchers with indexed profiles were identified. Because ResearcherID coverage is incomplete and profiles do not provide a standardised or consistently available basis for gender identification, these data were not used as the primary method for gender classification.

4.3 Gender assignment

Binary gender (female or male) was inferred from given names using the gender-guesser Python package, which employs a curated database derived primarily from census and public naming datasets. Each unique given name from both first and last authorship positions was compiled into a master list (~ 200-300, depending on de-duplication), and the classifier returned one of several labels: male, mostly_male, female, mostly_female, andy (androgynous), or unknown.

For analysis, these outputs were collapsed into three categories:

- M (male): classifier returned male or mostly_male
- F (female): classifier returned female or mostly_female
- X (indeterminate): classifier returned andy, unknown, or no meaningful name was supplied

Names were automatically assigned to category X when:

- only a single initial or two-letter string was present;
- the given name ended in a period (e.g., "J.");
- the string did not match any entry in the gender database; or
- the author provided only a surname.

This approach reduces the risk of misclassification by retaining ambiguous cases as indeterminate (X), but it does not eliminate uncertainty, particularly where probabilistic classifications are used. Importantly, the indeterminate (X) category refers to authorship instances across the full publication corpus and should not be confused with the much smaller ResearcherID validation subset used solely for author-name harmonisation.

4.4 Identification of female-led publications

A publication was classified as female-led if the first author was assigned "F". A publication was classified as female senior-authored if the last author was assigned "F". Publications with indeterminate "X" first or last authors were retained in the dataset and included in overall counts but were not classified as either female- or male-authored for categorical comparisons. Percentages of female, male, and indeterminate authorship were calculated relative to all publications for that authorship position, including those classified as indeterminate (X). All counting and summarisation procedures (e.g., number and percentage of female first authors, female senior authors, and the intersection of both roles) were conducted in Python using simple filtering operations in pandas.

4.5 Temporal trends in authorship

To examine change over time, multi-author publications were grouped by year (2016–2025). For each year, we calculated the percentage of publications with female, male, or indeterminate first authors and, separately, the percentage with female, male, or indeterminate (X) last authors, using the total number of multi-author publications in that year including those classified as indeterminate (X), as the denominator. Annual percentages were calculated within each year to account for variation in total publication volume across the study period.

4.6 Limitations

Gender assignment based on given names reflects a methodological constraint inherent to bibliometric analyses. Names do not capture self-identified gender, do not account for non-binary identities, and cultural naming practices vary, with some authors publishing under initials. In addition, the gender-guesser database is derived primarily from Western and Anglophone naming datasets, and Web of Science indexing does not comprehensively represent global scholarship, both of which may bias the dataset toward Western contexts and reduce classification accuracy for non-Western names. Indeterminate classifications may disproportionately include authors from regions or naming traditions underrepresented in Western naming databases. Retaining indeterminate (X) cases was an intentional methodological decision aimed at avoiding unsupported assumptions about gender identity in ambiguous cases. Excluding these records would require assuming that unidentified names are missing at random with respect to gender, geography, and naming convention, which is unlikely in a global bibliometric dataset.

By including an indeterminate (X) category, we reduce – but do not eliminate – forced classification where gender cannot be reliably inferred. Because this analysis is based on publication-level authorship positions rather than unique individuals, authors or teams with higher publication output may contribute disproportionately to overall percentages and influence observed patterns of gender representation. Author-level analyses, which account for the number of unique individuals contributing to publications, would provide complementary insights but were beyond the scope of the present study. Given the historical male predominance in many scientific fields, the gender disparities reported here may represent conservative estimates if a substantial proportion of indeterminate authors are male.

5 Results

Our Web of Science search returned 12,642 peer-reviewed publications related to sharks and other elasmobranchs between 2016 and 2025. These records included journal articles and review articles and together represented the global output of elasmobranch research over the past decade. Across all publications, the mean number of authors per paper was 5.64 (SD = 5.19), with a median of 5 and a mode of 4 authors, indicating a strong skew toward multi-authored collaborative research. Only 4.64% of all publications (587 of 12,642) were single authored (Figure 1). All authorship counts reported below refer to publication-level authorship positions (i.e., first and last authors per paper), rather than unique individuals. As a result, the same individual may be represented multiple times across publications, potentially biasing estimates of gender representation if publication productivity varies systematically among individuals or demographic groups.

Among these single-author publications, 109 were classified as female-authored, 291 as male-authored, and 187 as indeterminate (X). These indeterminate (X) classifications arose from incomplete, ambiguous, or non-classifiable name information within the publication dataset and should not be confused with the separate ResearcherID validation subset used for author-name harmonisation. Retaining indeterminate cases was an intentional methodological decision aimed at avoiding unsupported gender assignment where names could not be classified with reasonable confidence. Excluding these records would require assuming that unidentified names are missing at random with respect to gender, geography, and naming convention, which is unlikely in a global bibliometric dataset. Given the historical predominance of men in many scientific disciplines, the observed disparity between female- and male-authored publications may therefore represent a conservative estimate if a substantial proportion of indeterminate authors are male, although the true composition of the X category cannot be determined reliably from the available data. Most publications (95.36%) involved more than one author. Within this multi-author subset, first authors were classified as female in 3,664 publications, male in 4,955, and indeterminate (X) in 3,436. As with single-author publications, the relatively large proportion of indeterminate first-author classifications introduces uncertainty into estimates of the magnitude of the observed authorship disparity. However, retaining these cases explicitly avoids imposing assumptions about the underlying gender composition of ambiguous or non-classifiable names.

We additionally quantified papers in which both the first and last author were women. Across all multi-author publications, 1,036

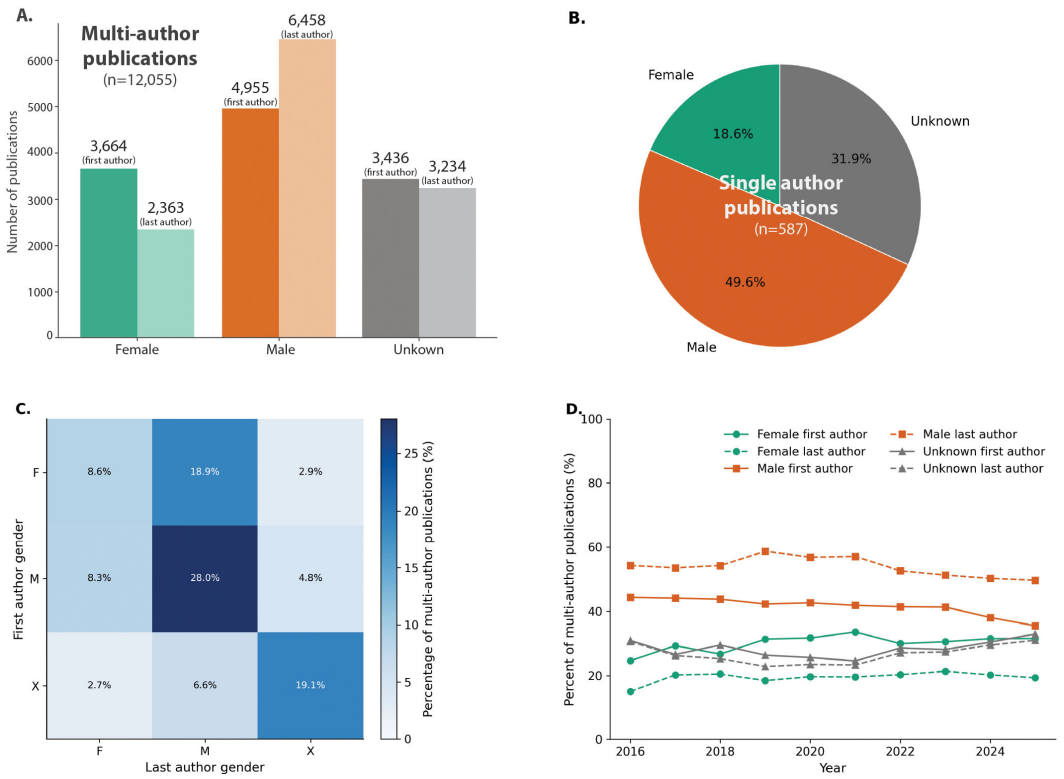

FIGURE 1
Authorship structure and gender representation in elasmobranch research publications (2016–2025). **(A)** Distribution of inferred gender among first and last (senior) authors for multi-author publications (n = 12,055). Female authorships are shown in teal, male in ochre, and indeterminate (X) in grey. **(B)** Gender distribution of single-author publications (n = 587). The proportion of publications authored solely by women, men, or individuals of indeterminate (X) gender is shown. **(C)** Joint distribution of first–last author gender combinations for multi-author publications, expressed as the percentage of all multi-author papers falling within each of the nine possible pairings (F/M/X × F/M/X). Darker shading indicates higher proportions, with the female–male and male–male combinations being most frequent. **(D)** Temporal trends in authorship gender across multi-author publications from 2016 to 2025. Plotted values represent the annual percentage of papers with female, male, or indeterminate (X) first authors (solid lines) and last authors (dashed lines).

papers met this criterion, corresponding to 8.59% of multi-authored output (Figures 1A–D). Together, these findings establish a quantitative baseline for evaluating patterns of gender representation in elasmobranch science. Notably, although female first authorship was consistently higher than female senior authorship, the separation between these trajectories persisted across the decade (Figure 2). To more explicitly quantify the separation between these trajectories, we calculated the annual difference between female first- and last-author percentages (FA – LA; Figure 2). This derived metric shows that the disparity between first- and last-author representation remained consistently positive across the decade, indicating that increases in female first authorship were not accompanied by a proportional increase in representation in last-author positions. A complementary pattern is observed for male authors, who are more frequently represented in last-author positions relative to first authorship across the study period, reflecting an inverse distribution to that observed for female authors (Figure 2).

Because these results are based on publication-level counts rather than unique individuals, they should not be interpreted as direct measures of career progression or transitions between authorship roles. Although first- and last-author positions are often associated with different career stages, they remain imperfect proxies, and this analysis does not track individual researchers over time.

The observed disparity between first- and last-author representation is consistent with broader evidence of cumulative disadvantage in academic careers, including homosocial recruitment and attrition across career stages (24, 25). However, these findings describe patterns in authorship distribution rather than the mechanisms driving them. Furthermore, as this analysis does not estimate the underlying gender distribution of researchers in elasmobranch science, authorship proportions should not be interpreted as direct measures of representation relative to the field as a whole.

6 Moving forward: making elasmobranch science more equitable and impactful

To build a resilient and innovative discipline, institutional commitment must move from rhetorical endorsement to structural reform. Community-led initiatives like Minorities in Shark Sciences (MISS), The Gills Club, and Women in Ocean Science have pioneered this transformation, but closing the "leaky pipeline" requires a fundamental retooling of institutional frameworks. This necessitates an intentional shift away from informal, identity-based networks and informal norms that have historically shaped perceptions of field competency. To evolve, elasmobranch science must replace hand-picked loyalist systems with transparent, skill-based frameworks for recruitment and mentorship, ensuring that at-sea experiences are safe, accessible, and free from harassment (26).

Advancing equity also requires addressing systemic gaps in primary authorship and grant acquisition, where women, particularly those from the Global South, remain underrepresented. We must advocate for "inclusive publishing pipelines" that account for career interruptions and prioritize diverse contributions beyond traditional citation metrics. Without structural interventions to support women in leadership roles, the field risks losing scientific talent and narrowing the expertise necessary for effective conservation.

However, these efforts must recognize that the "woman's experience" is not monolithic. Intersectionality is essential to address the compounded barriers faced by Indigenous and First Nations women, LGBTQIA+ scientists, and early-career researchers. For example, Indigenous women often hold vital Traditional Ecological Knowledge, yet their contributions are frequently sidelined in Western academic frameworks. Equity requires that women

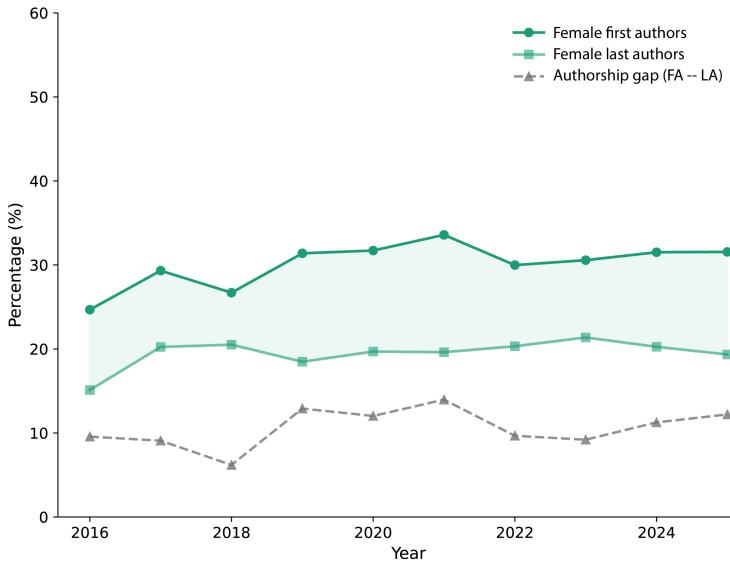

FIGURE 2
Temporal dynamics of the first-versus-last authorship disparity in elasmobranch research (2016–2025). Annual percentages of multi-author publications with female first authors (circles) and female last (senior) authors (squares) are shown for the period 2016–2025. The disparity metric (triangles) represents the difference between the percentage of publications with female first authors and those with female last authors (FA – LA) for each year. This derived metric explicitly quantifies the separation between the two trajectories shown in Figure 1D and allows assessment of whether the disparity between authorship positions is narrowing, widening, or remaining stable through time.

from all backgrounds hold positions of shared leadership within systems redesigned to support their success.

The benefits of structural equity extend beyond representation. Evidence indicates that gender-balanced leadership is associated with greater innovation and improved conservation outcomes (27, 28). As global biodiversity targets approach, broadening leadership within elasmobranch science is a strategic necessity.

7 Call to action: from intent to implementation

While progress is noticeable, persistent gender equity imbalances remain in marine science, and numerous studies have examined these issues and proposed potential solutions (6, 29, 30). Among these studies, de Vos et al. (31) and Kaikkonen et al. (32) provided a comprehensive overview of gender equity issues in ocean sciences and interdisciplinary marine sciences, respectively, and both proposed a range of actions to improve inclusivity within the field. Their recommendations include advocating for and creating opportunities for women and LGBTQIA+ individuals within the research community; developing and implementing codes of conduct to address discrimination and harassment; and promoting individuals from underrepresented groups through awards, leadership roles, and invited talks at conferences. Institutions are encouraged to provide anti-sexism training for staff, allocate more resource towards gender equity, establish safe and confidential mechanisms for reporting misconduct, and develop standardized protocols to collect data and monitor progress toward equity. Funding agencies also have a responsibility to ensure more equitable grant allocation across genders. Finally, publishers can contribute by adopting double-blind peer review to reduce evaluation bias, ensuring gender balance within editorial boards, and systematically collecting data on the gender of authors and reviewers to track equity outcomes. While these recommendations are directly applicable to elasmobranch science, the patterns reported here also align with evidence from many other scientific disciplines, suggesting that the observed authorship disparities reflect broader structural processes operating across academia rather than phenomena unique to elasmobranch research. We further propose additional measures aimed at advancing gender equity beyond existing frameworks.

Institutions and Funders: We urge academic and governmental institutions to move beyond diversity statements to measurable structural reform. This includes implementing equitable funding mechanisms that account for gender-based career interruptions and providing long-term support for mentorship networks.

Journals and Editors: Scientific journals must actively address bias in the peer-review and publication process. Prioritizing the visibility of women and underrepresented researchers through "inclusive publishing pipelines" is essential to diversifying the historical record of elasmobranch research.

The Global Research Community: We encourage our colleagues to intentionally amplify the work of women, early-career researchers, and scientists from the Global South. This involves diversifying citation practices, creating safe and inclusive field environments (26), and ensuring that authorship reflects genuine collaboration rather than "helicopter science". Parity should be the norm for invited speakers and conference representation.

The path forward requires measurable accountability in recruitment, funding, authorship, and promotion. Ensuring that participation translates into leadership is essential to the intellectual resilience of the discipline. As elasmobranch populations depend on ecological diversity for resilience, so too does the science devoted to their conservation depend on diversity in participation and leadership.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

JS: Conceptualization, Writing – original draft, Writing – review & editing. JM: Writing – original draft, Writing – review & editing. JR: Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing.

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