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POINT-OF-VIEW

Goals, challenges, and next steps in transdisciplinary fisheries research: perspectives and experiences from early-career researchers

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Abstract Fisheries are highly complex social-ecological systems that often face 'wicked' problems from unsustainable resource management to climate change. Addressing these challenges requires transdisciplinary approaches that integrate perspectives across scientific disciplines and knowledge systems. Despite widespread calls for transdisciplinary fisheries research (TFR), there are still limitations

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in personal and institutional capacity to conduct and support this work to the highest potential. The viewpoints of early career researchers (ECRs) in this field can illuminate challenges and promote systemic change within fisheries research. This paper presents the perspectives of ECRs from across the globe, gathered through a virtual workshop held during the 2021 World Fisheries Congress, on goals, challenges, and future potential for TFR. Big picture goals for TFR were guided by principles of co-production and included (i) integrating transdisciplinary thinking at all stages of the research process, (ii) ensuring that research is inclusive and equitable, (iii) co-creating knowledge that is credible, relevant, actionable, and impactful, and (iv) consistently communicating with partners. Institutional inertia, lack of recognition of the extra time and labour required for TFR, and lack of skill development opportunities were identified as three key barriers in conducting TFR. Several critical actions were identified to help ECRs, established researchers, and institutions reach these goals. We encourage ECRs to form peer-mentorship networks to guide each other along the way. We suggest that established researchers ensure consistent mentorship while also giving space to ECR voices. Actions for institutions include retooling education programs, developing and implementing new metrics of impact, and critically examining individualism and privilege in academia. We suggest that the opportunities and actions identified here, if widely embraced now, can enable research that addresses complex challenges facing fishery systems contributing to a healthier future for fish and humans alike.

Keywords Social-ecological systems · Sustainability · Knowledge transformation · Co-production · Institutions · Mentorship

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Introduction

Fisheries science as a research discipline has made important intellectual contributions to some of the world's most complex environmental and societal challenges. Western fisheries science was initially developed to support the management of economically valuable commercial fisheries in the global north, focusing primarily on biological factors that regulate fishery productivity, or on stock assessment models to establish maximum sustainable yield and high economic output (Beverton and Holt 1957; Halliday and Pinhorn 1996; Halliday and Fanning 2006). Fisheries research and management now span diverse ecosystems around the globe in the service of various fisheries sectors (e.g., small-scale, ceremonial, recreational).

More recently, fisheries have been characterized as social-ecological systems (Ommer and Perry 2011), which address the complex interactions and multiway feedbacks that exist among diverse actors, target species, and ecosystems (Schlüter et al. 2012). The study and management of fisheries are thus characterized by high levels of uncertainty. Widespread and rapid changes in the world's aquatic ecosystems alter social-ecological relationships and can have profound effects on the livelihoods and lifeways of local communities (Andrews et al. 2020). The challenges facing fisheries as an industry, livelihood, and research discipline span disparate yet interconnected topics including governance, economics, food security, poverty alleviation, biodiversity conservation, climate adaptation, and social justice (Chuenpagdee and Jentoft 2019). These complex challenges have been recognized in the fisheries literature as 'wicked problems' (Jentoft and Chuenpagdee 2009; Turgeon et al. 2018); i.e., problems characterized as multi-dimensional, difficult to define, evolving, having competing and intrinsically diverse interests and conflict types, and without a single or immediate solution (Rittel and Webber 1974).

It is widely accepted in current fisheries research that no single discipline, source of knowledge, sphere of experience, or area of expertise can independently address the 'wicked problems' faced by fisheries (Jentoft and Chuenpagdee 2009; Haapasaari et al. 2012; Glavovic et al. 2015). For example, finding equitable and sustainable solutions for communities coping with large-scale environmental change (e.g., climate change) may require integration of community-based knowledge (e.g., local knowledge of ecosystem function), and data from social sciences (e.g.,., decision making processes, social dynamics of adaptation), economics (e.g., impact on value chains), political science (e.g., policy creation, governance theory), and ecology (e.g., responses of the biological community to environmental stress). Indeed, such questions necessitate a broad integration of perspectives across academic disciplines and knowledge systems. In some cases, local ecological knowledge (e.g., experiences, perceptions, stories, anecdotal information) has improved governance of fisheries resources by providing otherwise elusive insights that add to our collective understanding of the social-ecological dynamics of fishery systems (examples in Johannes et al., 2000; Azzurro 2011; Eckert et al., 2018). Although some fisheries challenges may have straightforward solutions, the complexity of many of these problems demand that fisheries research 'transcend science' by drawing on diverse knowledges. In this way, the research process and outcomes can better attend to the needs and values of diverse rights holders, local communities, practitioners, resource managers, and decision-makers (Cvitanovic et al. 2015; Chuenpagdee and Jentoft 2019; Reid et al. 2020; Barnes et al. 2021; Kadykalo et al. 2021a). The uptake and application of

transdisciplinary methodologies are increasingly recognized as effective at finding solutions to complex and dynamic problems facing fisheries and developing equitable and legitimate management approaches (Turgeon et al. 2018). Transdisciplinarity extends beyond multi- and interdisciplinary methodologies that incorporate collaborative elements and integrate data across academic disciplines (Klein 1990) to support cooperative approaches and partnerships which enable knowledge exchange across science-policy-practice divides (Turgeon et al. 2018; Bennett 2019; Kelly et al. 2019; Barnes et al. 2021).

Transdisciplinary approaches have spurred the development of new frameworks for managing and studying fisheries, many of which have roots or direct parallels with long-standing approaches to looking after fisheries (e.g., Indigenous fisheries that commonly manage whole systems and are inherently adaptive; Berkes 2018). Two of these frameworks, i.e., ecosystem-based fishery management (Macher et al. 2021) and adaptive co-management (Armitage et al. 2010; Stöhr et al. 2014), emphasize the need for integrative approaches that move beyond just biological considerations and consider the social, ecological, economic, and institutional dimensions of fisheries (Turgeon et al. 2018). Within these frameworks, the roles of scientists have shifted. Researchers must become fluent in diverse disciplinary 'languages' (Andrews et al. 2020), learn complex communication skills (Macher et al. 2021), navigate when their voices are critical and when they are not as useful (Chuenpagdee and Jentoft 2019), and learn how to respectfully combine and uphold the validity of multiple knowledge types (Steelman et al. 2019; Reid et al. 2020; Barnes et al. 2021). In addition, researchers are taking on new responsibilities at the science-policy-practice interface (Cvitanovic et al. 2015; Fabian et al. 2019; Kadykalo et al. 2021b) and must learn how to frame their findings in a way that is relevant to decision-makers. Engaging in transdisciplinary fisheries research (TFR) requires substantial investments in time and training to navigate the co-production of knowledge with diverse partners who may have different management goals, accessibility to information, and communication styles or needs (Mauser et al. 2013; Evans and Cvitanovic 2018; Kelly et al. 2019; Andrews et al. 2020).

These demands can be intense, particularly for early career researchers (ECRs) (Chapman et al. 2015; Turgeon et al. 2018; Kelly et al. 2019). Despite widespread calls for transdisciplinary research, there are still barriers in personal, financial, technical, and institutional capacity to carry out and support TFR. Proper training can be difficult to offer and access, and opportunities to discuss common goals and strategize best practices are limited. To provide a forum for such critical dialogue, we held a global collaborative workshop for ECRs who work or aim to work in TFR. The objective of the workshop was to gather the perspectives of ECRs to identify big picture goals for the field, characterize and understand the main barriers for conducting TFR, and identify actions for researchers and institutions that can enable TFR. The goal of this paper is to share reflections from that workshop to spark dialogue and prospective thinking on the goals, challenges, and future potential for this expanding field.

Methods

Our workshop took place on September 21, 2021, as part of the World Fisheries Congress (WFC) in Adelaide, Australia (held virtually due to the COVID-19 pandemic). We assembled a diverse international team of fisheries researchers in early career stages who use or aspire to use transdisciplinary methodologies in their work. We define 'early career' to include graduate students in Master's or PhD programs, as well as professionals in the first five years following their highest degree.

After registering for the WFC, participants could sign up for the workshop online on a first-come first-served basis (with a limit of 20 spots in the initial registry) if they qualified as an ECR and identified the ongoing or potential for transdisciplinary research in their field. Other participants were recruited via targeted invitation to offer spots to ECRs who missed the online sign-up window, and to fill gaps in global representation (although still drawn from within the WFC pool). Targeted recruitment (led by EAN) involved reading titles and abstracts of registered WFC participants and emailing invitations to individuals who fit the target demographic. In total there were 29 participants: four organizers (EAN, AJR,

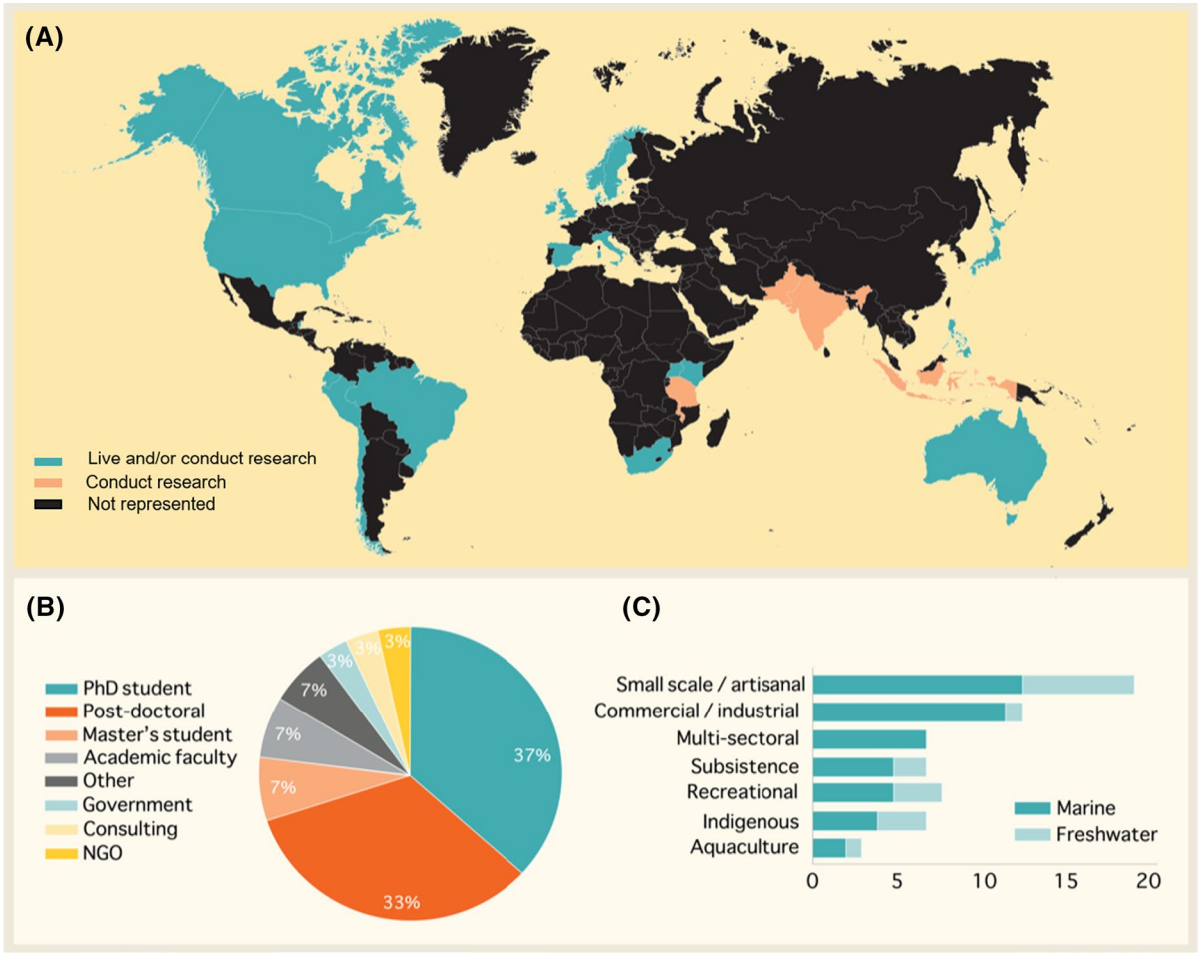

Fig. 1 **A** Countries of residence and/or research location of the author team. Countries shaded blue (darker tones) are where members of the author team reside and/or carry out research. Countries shaded orange (lighter tones) are where members of the author team conduct research but do not reside. See Appendix A1 for full list. **B** Career stages and sectors of participants. **C** Types of fisheries represented by participants in the workshop (participants could choose more than one)

ALJ, SJC), 16 sign-ups, and nine recruits. Among the recruits were two individuals (RK, MM) who were asked to co-lead the workshop based on their expertise in the field. All participants who contributed to the activities before, during and after the workshop are co-authors on this manuscript, with representation from 26 countries across six continents (Fig. 1a, Appendix A1). Most participants were in the academic system at the graduate student or postdoctoral level, although some participants hailed from the consulting, practitioner, government, and non-governmental (NGO) sectors (Fig. 1b). The types of freshwater and marine fisheries represented were from the commercial, small-scale, Indigenous, subsistence, recreational, and aquaculture sectors (Fig. 1c) as defined by the Food and Agriculture Organization of the UN (FAO 2012).

The organizers and workshop facilitators aimed to foster inclusivity, diversity, and equitability as much as possible. To reduce language barriers, we used online translation tools (e.g., *Google Translate*) to translate all written documents and communications into requested languages and employed closed captioning during the *Zoom* session. Additionally, we provided live technical support during the Zoom meeting, and saved all video recordings, chat logs,

and transcripts to share with participants after the meeting. Multiple models of participation outside of the live workshops were offered to participants to accommodate individuals with poor internet connections or time zone conflicts. For example, we used online forms, interactive *'Mural'* boards (https://www.mural.co/), and opportunities for post-workshop reflections (via e-mail).

The exercise of building the knowledge base for this article proceeded in three stages: (i) a pre-workshop individual brainstorming session, (ii) a three-hour live *Zoom* (https://zoom.us/) event (i.e., the workshop), and (iii) post workshop reflections and writing. For the brainstorming session, each participant was asked to complete an online survey via *Google Forms* in the week prior to the workshop to provide details about research interests and thoughts on two key questions. These questions were:

1. Based on your experience as an ECR, what do you believe are key goals for TFR in the future? Think about intellectual challenges and important areas of future research to guide the field and to produce knowledge that is important for sustainable fishery systems.
2. What are some challenges faced by ECRs working in transdisciplinary settings? How can these barriers be overcome? For each challenge, please identify a possible solution

The brainstorming session provided time to contemplate discussion points and ensured that all voices were heard regardless of whether people could not attend the workshop or preferred to be less vocal in the workshop setting. Responses were submitted up to one day before the workshop. Responses were then read by two organizers (ALJ, EAN) and rapidly collated and categorized into four key themes for each discussion question before the workshop (Appendix A2).

For the workshop, we established an ethical and respectful community of practice by opening with a land acknowledgement (led by AJR) that invited participants to reflect on the place they were joining from, recognizing the unique and enduring relationship that exists between Indigenous Peoples and their traditional land and territories. We felt such acknowledgements were important steps to recognizing the need to reduce the harms of colonialism—especially in transdisciplinary fisheries research which is partially concerned with reconciling relationships between Indigenous and non-Indigenous Peoples, and nature. Participants were then given time to introduce themselves and their personal research backgrounds to the group. One hour was allotted per question to consider and discuss thoughts on each topic. First, a summary of the online responses (led by ALJ) was presented, and then participants were assigned to three breakout groups. Workshop leaders guided the discussion and kept notes, and participants could provide input orally or by using interactive *Mural* boards to write down key points. A short plenary followed each breakout period to share highlights. The workshop closed with reflective words from a later career mentor and established TFR colleague (SJC).

After the workshop, a systematic analysis was conducted on all outputs. The *Mural* boards from each breakout group were first analyzed separately by categorizing 'sticky notes' into themes within each board (Appendix A3). Perspectives from the three *Mural* boards were then combined and grouped into larger categories including: *goals*, *barriers, considerations for researchers*, and *actions for ECRs, established researchers, and institutions*. To ensure all participants' points and concerns were captured accurately, the *Zoom* video recordings were transcribed in full. A codebook was developed through inductive processes and refined over two rounds of coding (conducted by EAN, Appendix A4). The first round of coding was used to categorize and summarize the data into broad themes, and the second round was used to focus on specific sub-themes and categories that emerged from the *Mural* board analysis. Subsequently, the responses from the *Google Form* were cross-checked with themes and categories that emerged from the workshop.

The ECRs in the workshop (i.e., the authors, herein referred to as 'we') provide a synthesis of perspectives emerging from the *Google Form*, *Zoom* workshop, and post-workshop reflections. We outline big-picture goals for TFR as a field and match each goal with high-level considerations for researchers conducting TFR. Next we discuss key barriers to conducting TFR and identify several specific actions for ECRs, established researchers, and institutions that can enable this type of work (Fig. 2). We include three boxes with examples of extant strategies or new models of action for how changes to current

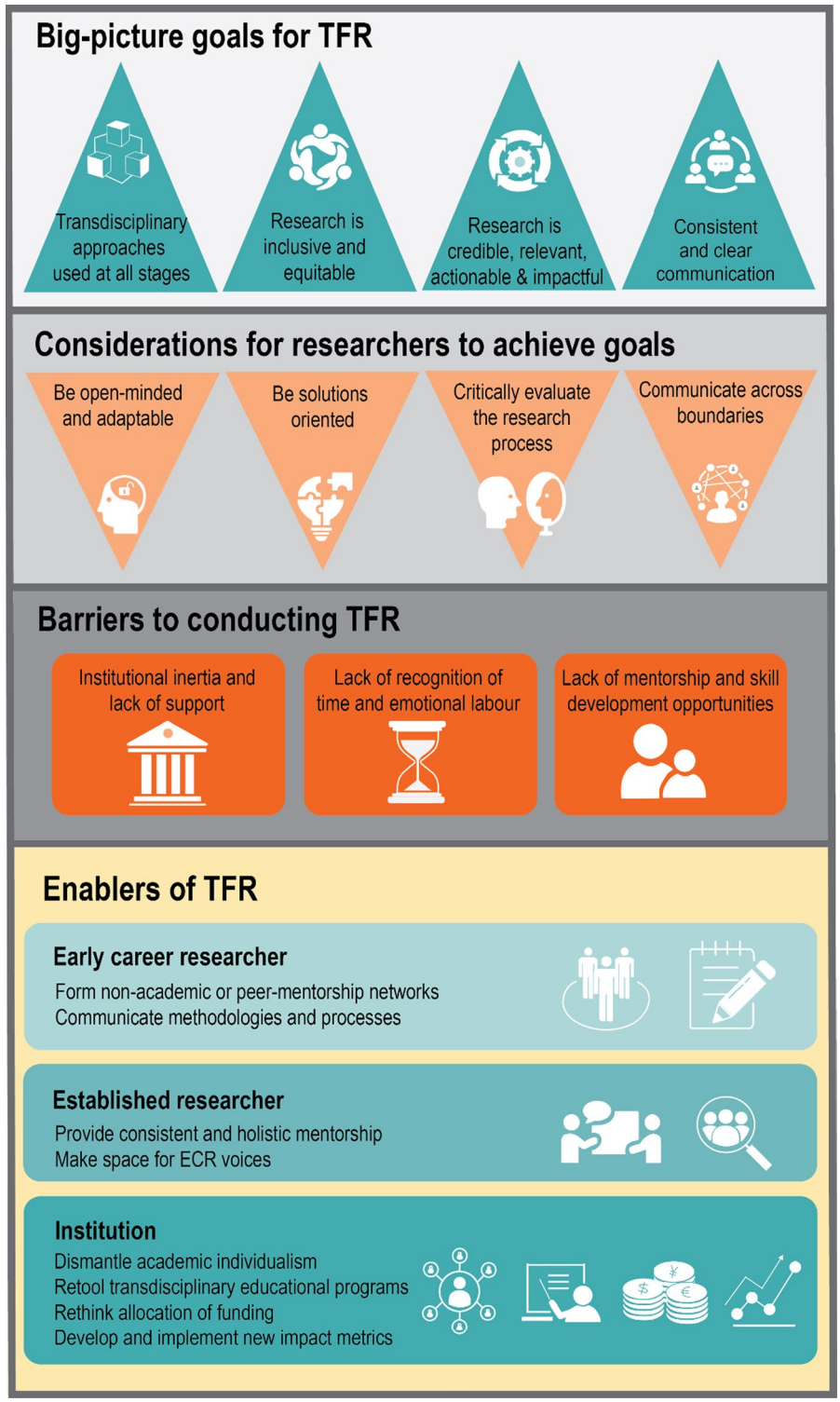

Fig. 2 Diagram outlining key points in each of the part of the manuscript: goals and considerations, barriers, and actions that can enable TFR

norms can be made; boxes are based on participants' experiences.

Given the broad range of perspectives and contexts represented in our workshop, goals, considerations, barriers, and actions that we present are unsurprisingly generic. We acknowledge that variations in political situation, governance approach, industry standard, and economic capacity among fisheries, regions, countries, continents, and the global north vs. global south mean that translating our suggestions into achievable actions will look different across geographies and contexts. Barriers and challenges will be substantially higher in regions with less support and funding for TFR (i.e., much of the global south). We further acknowledge that despite our collaborative approach, the group of people whose views are presented here does not entirely represent the perspectives and experiences of all global ECRs. Our team was drawn from individuals able to attend an online international congress, and thus excludes those without access or resources to attend. Despite these limitations, we observed parallel experiences and congruity of responses among participants. This manuscript was developed collaboratively with all authors (i.e., workshop participants); the views presented below are thus broadly representative of the experiences of the ECRs who attended this workshop, and likely have relevance in the broader context of TFR.

Workshop outcomes

A first critical step to any fisheries research project will be to determine whether transdisciplinary approaches are indeed necessary to answer the question at hand. We suggest researchers should use a transdisciplinary approach any time there are diverse and competing ways of understanding the problem (cause, effect, and solution), and when outcomes carry high stakes for multiple actors (Pohl and Hadorn, 2007). The following goals, considerations, barriers, and actions assume that a transdisciplinary approach has already been determined to be appropriate for a given research agenda.

Big-picture goals and considerations for transdisciplinary fisheries research

We identified that crucial aims for TFR are to dismantle traditional disciplinary and institutional silos through processes of co-production, and to find innovative solutions to complex fishery problems by forming novel alliances and collaborations among interested partners. Below we outline four big-picture goals that fit under these aims along with considerations that can help researchers achieve those goals.

Goal 1: Embody transdisciplinary approaches during all stages of research

A broad consensus on what it means to conduct a successful TFR was that it requires the integration and merging of disciplines, knowledge types, and perspectives from diverse actors during all stages of the research process. This integration must be evident from project conception and question formulation through implementation and dissemination. Researchers must therefore engage with fisheries as social-ecological systems and use holistic approaches for solving complex fisheries challenges. Critically, such approaches require understanding and prioritizing the social, political, and cultural contexts of fisheries so that human dimensions are integrated into decision-making processes and so that participatory management and co-management are enabled. Although this goal may seem obvious to some, we discussed how transformative action is still often impeded by siloed research conducted without broader context or connection to other disciplinary or knowledge domains (see *Barrier 1*). Therefore, this first goal is a critical one that is still far from being met and sets the stage for the remaining goals, considerations, and actions.

Consideration 1: Be open-minded and adaptable

A consideration for researchers to achieve Goal 1 is to be flexible and willing to evolve throughout the transdisciplinary research process, beginning at project inception. Overarching this consideration is the recognition that the process of conducting the research is as important for learning and finding

solutions as the end goal or final outcome. Collaborating in ways that ensure all parties have equitable opportunities to express their views, embracing other ways of knowing (i.e., practical, experiential, and community-based knowing) (Kelly et al. 2019) and adopting a Two-Eyed Seeing approach (i.e., seeing with one eye with the strengths of Indigenous knowledges and with the other with the strengths of Western knowledges; Reid et al., 2020) are all approaches that can allow researchers to adapt and embody transdisciplinary thinking throughout a project. Being willing to rethink, adjust, and pivot on research goals and approaches can ultimately support lasting relationships in projects and maintain the societal relevance of the end products (Wilson et al. 2021).

Goal 2: Ensure fisheries research is inclusive and equitable

We indicated that for fisheries research to be inclusive and equitable it is essential that studies are co-designed and co-produced (sensu Cooke et al. 2021a) with all actors in the fishery system that are affected by the problem at hand. We suggest that to be inclusive, TFR requires new ways of listening, improved mechanisms of communication, and increased opportunity for engagement by groups typically excluded from the research process. If we isolate fisheries research from the people who constitute a fishery, we will miss the very goal of the research and undermine the likelihood that its outcomes will be accepted, impactful, and fair (see *Goal 3*; Johannes 2000). It was deemed critical that TFR should explicitly address inequalities by enabling and empowering marginalized and/or vulnerable groups to take part in research and have their voices heard.

Consideration 2: Critically evaluate the research process and our role within it

Researchers can promote inclusivity and equity in the research process by engaging in bias recognition and reduction and examining one's positionality within a research team. We discussed the importance of being aware that our research process, from question formulation to interpretation of findings, is shaped by our own socially and politically situated values, biases, and assumptions. We must therefore examine our motivations and think critically about our context (e.g., colonial, western, privileged, etc.). This requires allocation of time to listen to collaborators or partners, to build sincere relationships founded on trust, to be transparent about project methods and goals, and honest about personal capacities and limitations (Mackinson, 2022; Cvitanovic et al. 2021a). By being self-reflexive, humble, and honest, we can be more empathetic and conscious and reduce potential condescension on behalf of academia (see *Institutional Action 1*). This can dismantle a sense of hierarchy or power imbalance that may discourage people from participating in the research process and could create barriers or prevent uptake of recommendations. Taking these steps can ensure that the research itself is not part of the problem through the exclusion of marginalized voices, tokenization of non-academic partners, or infliction of direct harms through research (i.e., why "research is a dirty word"; Smith 2021). For more information see Eigenbrode et al. (2007), who curated a 'toolbox for philosophical dialogue' consisting of questions for self-examination that cross-disciplinary collaborators can use to identify and address disparities and commonalities.

Goal 3: Design fisheries research so that it is credible, relevant, actionable, and impactful.

The third big-picture goal was for TFR to provide transformative solutions to complex fishery challenges by designing research that is credible, relevant, actionable, and impactful. This goal is closely connected to Goal 2 as making research credible and relevant requires early and deep engagement with diverse peoples and bodies to understand non-academic needs, concerns, and requirements. This step allows us to find out what is relevant to stakeholder contexts rather than making external assumptions about those needs (Mackinson, 2022). Similarly, credibility and relevance are pre-requisite to the research findings being actionable and impactful. We suggested that key indicators of actionable and impactful research are that: (i) findings are used to inform policy or practice, (ii) findings are accepted

and taken up by industry or community partners, and (iii) findings improve the socioeconomic and ecological status of the fishery system. Although such outcomes are difficult to measure, we suggest a concrete step to ensuring impact is to engage in collaborative problem identification and framing and deciding on mutual benefits from early in the research process.

Consideration 3: Be solutions-oriented

 While most research focuses on identifying and defining problems, descriptive-analytical investigations have revealed a growing demand for studying and advancing solution options (Miller et al. 2014; Lang and Wiek 2021). We therefore advocate for a solutions-oriented approach to ensure that TFR is credible, relevant, actionable, and impactful. To accomplish this, it is important to move away from a sole emphasis on academic products (e.g., journal articles) and focus on outputs that can be implemented on the ground (e.g., co-management plans). Often, efforts to co-define research objectives and decide on equitable research outputs in partnership with interested and/or implicated parties improves the likelihood of solutions being accepted across sectors (e.g., Hobday et al. 2016; Österblom et al. 2020). We also indicated the need to build long-term trust with stakeholders and rights holders and encourage transdisciplinary approaches within management to achieve transformative action. This requires providing change-makers (e.g., NGO partners, community groups, policy makers) with solutions-oriented, measurable, actionable, and timely research (Sherman 2011; Chapman et al. 2015; Dlouhá et al. 2019) and ensuring that researchers are equipped with the mindset to do this work (Gale et al. 2021). There has been an increasing focus on how to achieve impact at the interface between science and policy (Cvitanovic et al. 2021b; Karcher et al. 2021). An accessible resource for ECRs seeking to achieve policy impact has been created by Evans and Cvitanovic (2018), in which they identify approaches to research as well as personal attributes to facilitate the relationships between science, policy, and practice. In addition, it is important to consistently evaluate and monitor the extent to which outcomes of TFR are actionable, impactful, and transformative so that we can improve or adapt our processes when needed.

Goal 4: Consistently and clearly communicate with all partners throughout a project

 We emphasized the need for consistent and clear communication with and among policy- and decision-makers, fisheries managers, governing bodies, and all relevant rights holder and stakeholder groups. In the long term, working to develop shared and multi-way communication and dialogue will support understanding and collaboration (Kelly et al. 2019) across and beyond disciplines, as well as between academic and non-academic actors. Facilitating open discussions could provide an essential mechanism for finding common ground and shared languages/goals to support and guide the transdisciplinary research agenda (Andrews et al. 2020).

Consideration 4: Communicate in ways that are sensitive to cultural and sectoral differences

 To achieve consistent communication with partners we discussed the need for alternative forms of knowledge exchange that are not exclusively aimed at academic audiences (e.g., to engage with diverse non-academically trained stakeholders and rights holders). It may be through means that could be adaptable (i.e., to the specific context), reflexive (i.e., evolving throughout the project), and solutions-oriented (i.e., tailored to stakeholder needs and interests). We emphasized that taking the time to understand stakeholders' communication preferences was critical (Wilson et al., 2021). For policymakers, fisheries managers, and government authorities, policy briefs, infographics and webinars might be suitable approaches. For communities and broader publics, plain-language summaries across a range of formats (e.g., pamphlets, podcasts, artwork, documentaries) may enhance attention and interest. There is strong evidence in the literature to suggest that photographs and videos can be effective means of communicating

information readily and evoking emotion, often being more memorable than written depictions (Monroe et al. 2009; Bobek and Tversky 2016). We suggest that transdisciplinary fisheries researchers consult with community and governance partners to determine the preferred mode, format, and frequency of communication and agree on a strategy to ensure all members of the team stay connected and informed.

Barriers to conducting transdisciplinary fisheries research

Although the big picture goals and considerations outlined above are useful for framing the direction of TFR, we also identified several barriers to conducting transdisciplinary work. Discussion of barriers was prominent during the workshop; however, we summarize them in three key points as details on barriers have been addressed in several recent works (Hein et al. 2018; Jarvis et al. 2020; Kelly et al. 2019; Österblom et al. 2020).

Barrier 1: Institutional inertia leads to lack of support for TFR

One of the key challenges raised in the workshop was the institutional inertia that results in a lack of support for TFR (see also Jarvis et al. 2020). During our training, many of us experienced inconsistencies between academic institutions' expressed enthusiasm for transdisciplinary work, and their inability to provide adequate financial, pedagogical, and structural support. We shared experiences of feeling isolated and disconnected without having a departmental home or being placed in departments where transdisciplinary approaches are misunderstood and underappreciated. We also experienced professional repercussions because of insufficient structures to support and evaluate TFR. For example, inadequate advisory committee makeup at graduate levels and lack of comments or feedback on social methods or critical theory are common given that fisheries researchers are often housed in natural science departments. The leaning in fisheries research toward natural over social science also translates into institutional preferences towards quantitative over qualitative research. We discussed how this apparent discrimination led to conflict between the desire to conduct TFR and the perception that this might be detrimental to career advancement (Hein et al. 2018).

The incongruity between intention and action described above for academic institutions also emerged in the realm of funding opportunities (Sievanen et al. 2012; Said et al. 2019), a barrier that was especially relevant for those of us living in developing countries that are already limited in research funds. We discussed difficulties in finding grants tailored to transdisciplinary work as well as lack of financial support to conduct dissemination of findings and community engagement. Generally, the sentiment was that funding systems are stagnant despite a purported desire to change. Funding agencies claim to be advancing transdisciplinary research; however, review and evaluation committees tend to favour straight-forward, low-risk projects that can be easily evaluated and measured for success. This is an example of culture within a system (sensu Schein 2017) reinforcing institutional and disciplinary norms.

Barrier 2: Lack of recognition for the additional time and emotional labour involved with TFR

Given the nature of TFR, longer timeframes are often required to conduct this work. Researchers must become fluent in multiple disciplinary languages, integrate knowledge across disciplinary and sectoral lines, and build trusting relationships with diverse partners (see *Goal 3*). We noted there is often a mismatch between the expected timelines to complete a Master's or PhD degree (2 – 4 years) and the time required to effectively do TFR (e.g., at least one year required just for relationship building). This issue connects to the notion of institutional inflexibility (Barrier 1), where some academic institutions enforce the same time constraints for all students of a particular degree regardless of the nature of the work at hand. Inflexible timelines are exacerbated by a lack of institutional support for low-residency models that can support the students' needs to be on-the-ground in a community and/or off-campus for extended periods (Klein 2009); looking to socially oriented disciplines (e.g., anthropology) can provide insight into other models. In addition, there is a considerable emotional cost associated with building relationships

and maintaining trust with partners as they require deep personal commitments and investments of one's time and energy. Additional risks (e.g., conflicts, missteps) involved in transdisciplinary work require yet further emotional investments to overcome. We also discussed how the metrics used to evaluate TFR are not oriented to facilitate or support the processes required to do this work well. Institutions identify and reward certain types of outputs (e.g., published papers) but undervalue others (e.g., strong community relationships, outreach, public service, extension works) which do not yet have adequate evaluation systems in place (see *Institutional Action 4*) (Davies et al., 2021). We discussed how much of our time is spent simply justifying to funding agencies, colleagues, and institutions why transdisciplinary approaches are useful, reasonable, and legitimate. Cumulatively, it was clear that the burdens associated with TFR work are high yet scarcely recognized, appreciated, supported, or alleviated. Without crucial support, researchers face exhaustion and burn-out from taking on these additional burdens, particularly ECRs who work under precarious conditions (see also Andrews et al., 2020; Christian et al., 2021; Filyushkina et al., 2022).

Barrier 3: Lack of mentorship and few opportunities for development of skills required to be effective transdisciplinary fisheries researchers

The third barrier identified was the lack of mentorship for TFR and few opportunities for skill development to be effective transdisciplinary researchers (see also Steiner and Posch 2006; Frisk and Larson 2011). Although skills required for TFR vary depending on the research context, training needs identified consistently among us included knowledge translation (e.g., speaking across sectors and disciplines and to non-academic collaborators), workshop facilitation, negotiation in complex social settings, and effectively synthesizing ideas across disciplines and sectors. All these skills require extensive knowledge exchange and knowledge translation (Lang et al., 2012; Pooley et al. 2014). While there are plenty of conceptual approaches presented in the literature on how to carry out effective knowledge exchange, we discussed how when it came to implementing those approaches in our work it was often down to trial and error. Context-specific training for community engagement was also noted to be lacking. Many of us had anecdotes where misunderstandings of research partners' approaches to fisheries resulted in difficult or awkward conflicts that took time and energy to resolve. The lack of training and guidance in these skills and practices has resulted in our having to independently search for mentors or colleagues within or outside of our organizations since resources were lacking within home departments.

Actions for ECRs, established researchers, and institutions to enable transdisciplinary fisheries research

In the following section we outline several key actions that can be taken by ECRs, established researchers, and institutions to help overcome barriers and enable TFR. We supplement these sections with three boxes outlining concrete strategies or new models for enacting change based on our experiences.

Actions for early career researchers

ECR Action 1: Develop a peer mentorship and/or community mentorship network

We discussed the importance of mentorship for developing as researchers and also for creating transdisciplinary collaborations and communities of practice that are more inclusive of non-academic partners. As ECRs, one step we can take is to identify mentorship or training gaps and proactively fill those gaps (see *Barrier 3*). We reflected on how peer-to-peer learning and knowledge exchange can diversify opportunities to collaborate and drive ECR innovation in transdisciplinary research (see *Box 1*; Pannell et al. 2019). Some of us highlighted existing initiatives that were beneficial, including the UN Ocean Decade's Early Career Ocean Professional Working Group—a global network that aims to develop inclusive and participatory approaches to drive innovative inter- and transdisciplinary ocean science solutions.

In addition, we discussed how attendance at conferences was often helpful; some of us mentioned experiences and training obtained at conferences that went beyond skills learned in graduate school. However, we also reflected on the need to extend networking and collaboration opportunities to those who do not typically have access to global conferences and scientific society memberships (e.g., minority / marginalized groups) (Andrews et al. 2020). We considered how regional- to global-scale early-career-led networks can mobilize ECR perspectives and amplify much-needed younger voices in science. This includes the development of co-mentorship and peer-mentorship opportunities and establishing guidance on seeking mentorship as an emerging ECR. Further, we deliberated how we could build stronger mechanisms for engaging with non-academic partners (i.e., Indigenous communities, NGO partners, conservation organizations, and community groups) in transdisciplinary research. In thinking on how to achieve this in practice, we reflected on the need to establish mentor/mentee relationships outside of academia that can support the development of engagement and communication skills. In the last decade, social media platforms such as Facebook and Twitter have provided a useful new tool to connect 'users' (i.e., ECRs looking for research positions, funding, collaborators, and projects) and 'providers' (i.e., universities, research institutes, policymakers, stakeholders, institutions); a well-organized, dedicated application or tool would be helpful to improve connections among peers and mentors.

BOX 1—Development of peer mentorship networks

Peer mentoring can provide a much-needed opportunity for ECRs to learn how to become more transdisciplinary researchers, providing training and support to move away from traditional academic working styles which are often highly hierarchical and centered on individual success. Peer mentoring can be done as groups or in pairs and provides academic, career, social and psychological benefits (Lorenzetti et al., 2019). The additional challenges faced by transdisciplinary researchers make peer mentorship particularly useful because it allows ECRs to cultivate long-term supportive professional relationships (Kensington-Miller, 2018), which are essential when traditional mentor/mentee relationships fall short. Peer mentorship also provides additional emotional support and encouragement (McGuire and Reger 2003), and assists ECRs with developing research skills and navigating academic institutions (Lorenzetti et al., 2019)

ECRs at the Research Institute for the Environment and Livelihoods (RIEL) at Charles Darwin University established a reading group to learn together about intersectional feminist values and how to apply them within the context of academia and environmental research. The group combines Mac Namara et al.'s (2020) peer mentoring model with a book club structure. Members take turns choosing topics for discussion, enabling them to consider how to work as researchers and support one another. Topics have included power dynamics encountered as ECRs, how success is measured in academia, and how to improve representation of marginalized voices. Learning together about the structural and cultural barriers faced by ECRs reveals the shortcomings of traditional approaches to academia. The group functions as a place to build relationships, share anxieties and successes, and learn from others' perspectives and approaches. The network also provides a safe space for voices to be heard and for critiques and self-reflection to occur. The lack of hierarchy in these relationships enables ECRs to learn together and construct their own work culture away from their own disciplines (Kensington-Miller, 2018).

ECR Action 2: Clearly describe and communicate processes and methods used in TFR

TFR is epitomized by the approaches, epistemologies, and methodologies involved in conducting this work. In TFR, the research process and type of methods used are as important in defining the overall impact of the research as the actual findings of the work. However, the complexities of these approaches can be challenging for ECRs to navigate. We discussed that there was often a lack of clarity in how to move beyond buzzwords (e.g., community

engagement, participatory research) towards implementing these techniques in practice (see *Barrier 3*). TFR papers often breeze over the details necessary to replicate methods, especially for social aspects of the work, instead paying greater attention to the quantitative and/or technical aspects of their methods (House et al., in press). This can leave ECRs asking: What is really involved in community engagement? How do we make participatory methods truly inclusive? How do we integrate these ideas into research activities? By presenting the details of our approaches (including the ambiguous aspects of transdisciplinary work), ECRs and senior researchers can build the legitimacy of these methods and provide guidance for other researchers. We emphasized that reflexivity and honesty are an essential part of this process (see *Consideration 2*), allowing us to identify when our ways of working might be perpetuating unhelpful norms or lacking necessary robustness. By sharing our successes and failures, we can provide a roadmap for other ECRs and practitioners to use as a starting point. However, it is important to acknowledge that ECRs cannot be open and self-critical unless supervisors and institutions support that; this type of vulnerability is not risk-free in academia and in other sectors, and we need to know we are not undermining ourselves in the eyes of our institutions and supervisors. Although TFR requires contextualized approaches, learning from others means that we do not all have to reinvent the wheel and tackle the process alone. Making this information available would enable others to draw from a wider community of practice and apply those lessons to their own contexts (Cundill et al. 2015).

Actions for established researchers

Established Researcher Action 1: Be available for consistent and holistic mentorship

We acknowledged that the best mentors are those who have engaged in effective transdisciplinary work and demonstrated long lasting, productive relationships with diverse partners. Although such mentors face the same inadequate budgets and timeframes as ECRs, we discussed some ways that established researchers could fulfill the challenge of providing strong, consistent, and ongoing transdisciplinary mentorship. Support during project development was identified as especially important to ensure adequate cross-disciplinary and methodological training, and to facilitate engagement with research partners (see *Barrier 3*). This initial support can provide ECRs with critical skills in specialized non-academic communication such as facilitation and negotiation, stakeholder engagement, and interacting with the policy realm (see also Brandt et al. 2013) (see *Barrier 3*). Further, we discussed how early introductions and training allowed us to forge ahead with less reliance on a single mentor and more on a network of colleagues. However, we emphasize that having a consistent mentor throughout a project is crucial. Established researchers have a responsibility to advocate for ECRs if there are institutional barriers to engaging across disciplines (see also Nash et al. 2003; Stokols 2014) (see *Barrier 1 & 2*). To help overcome the mono-disciplinary approach of many fisheries programs, we suggested that mentors can support ECRs in TFR by forging cross-campus collaborations (i.e., establishing inter-sectoral or interdisciplinary co-mentorships) and linking ECRs to mentors from diverse sectors and levels of experience (e.g., peers, a policy advisor in government, an Indigenous knowledge keeper; see *Box 1*). This may require mentors to recognize the limitations to their areas of expertise or consider alternative mentorship structures. For instance, ECRs mentioned that some of their most valuable mentorship experiences emerged from arrangements at conferences or other networks; this represents an opportunity for established researchers to engage in highly impactful mentorship arrangements with mutually agreed upon goals, plans, and communication/interaction mechanisms.

Established Researcher Action 2: Make space for ECR voices

Many of us expressed a perceived lack of agency in directing current and future priorities in fisheries research. We pointed out how it is common for ECR voices to be ignored or marginalized and noted that we are often told that we must be a 'generation of problem solvers' (e.g., Jeanson et al. 2020),

without being given the platform, the voice, or the funding to achieve this expectation. The general feeling in the group was that unless given a more prominent voice, we are collectively limited in what can be achieved because we are adhering to established ideas that are failing (*Barrier 1*). We indicated that it is important for ECRs to be involved in shaping research agendas but that changing the *status quo* requires action by established scholars. There are many ways in which established researchers can make space for ECR voices (Pannell et al. 2019; Brasier et al. 2020). For example, ensuring that ECRs are given slots as keynote speakers at conferences and gatherings. Secondly, we discussed the positive outcomes that arose when established researchers provided opportunities for ECRs to direct research within the field. An example where this is done well is in the Integrated Marine Biosphere Research project (IMBeR) which includes ECRs on their steering committee in guiding future research priorities. This facilitates capacity building and career development of ECRs and allows fresh insight to topics of relevance to the IMBeR Science Plan. Established researchers must have the courage and humility to realize the benefits that come from creating meaningful space for ECRs and demand such change (McPhearson et al., 2021).

Actions for institutions

Institutional changes are among the most difficult to enact due to institutional inertia and bureaucracy, but they are also perhaps the most transformative given the scale on which they occur. The ideas we present here are lofty, but sorely needed to realize the promise of TFR.

Institution Action 1: Be willing to critique and dismantle academic individualism and the academic "superiority complex"

We discussed how institutional barriers were often underpinned by the continued embrace of individualism and the so-called academic superiority complex (see *Barrier 1*). The academic system is oriented towards activities that yield individual-level benefit (e.g., promotion, awards) (see also Kemp et al. 2013). We expressed that a focus on individual activities opposes a transdisciplinary approach to solving complex fisheries challenges and suggested that there is a need to revise academic structures that limit collaboration (see *Goal 2*, Lewis et al. 2012). This requires rethinking who can do science and who is worthy of authorship (e.g., community partners (see *Box 2*). Some of us recalled instances where attempts to include community groups as authors on research papers were met with confusion and resistance (see *Barrier 1*). For example, some institutional bodies require project team lead to have extensive educational backgrounds and undervalue the long-standing baseline knowledge that, for example, elders within a fishing community possess. This can shift management decisions into the arms of less experienced but more educated individuals who have little-to-no cultural or experiential knowledge, which is the foundation of many local community elders and experts. This needs to be addressed in contemporary programs and policies to ensure equity and a place at the table for all voices (see *Goal 1, Box 3*). By recognizing that knowledge comes in many forms and from many different types of individuals, we have the potential to democratize research (Davies et al. 2021) and move closer to achieving collective transformative action (Strasser et al. 2019; Cooke et al. 2021b). We also discussed how academic individualism can manifest in insinuations from supervisors and committees that transdisciplinary approaches lack academic innovation or adequate rigor and novelty (see *Barrier 1*). We argue, in contrast, that the work of deconstructing a siloed academia is indeed innovation and can help to push the frontier of complex questions where traditional approaches have thus far failed. We suggest that academic institutions (i.e., universities, education programs, funders, journals, societies) need to embrace this kind of innovation in the same way that they would a new research technology or novel quantitative approach.

BOX 2—A case study on reimagining lab hierarchies

> The "Centre for Indigenous Fisheries" (CIF; launched in January 2021) at the University of British Columbia comprises a team of researchers who work together as just that – a *team*. The CIF's research is not about any one person, it's about all. As such, the group collectively decided against naming the lab after any one team member. Each

student in the CIF belongs to a research project that is partnered with Indigenous communities and/or organizations. Most students work in paired contexts, where they can support one another on interrelated aspects of a larger project or program. Students develop independently as well as collectively, receiving context-specific training and research support through these interactions, and each week team meetings are led by a student coordinator to discuss project progress. It is through this multilayered mentorship model, which will soon be bolstered by an Indigenous Advisory Council for the CIF (launching in 2022), that student training needs are fulfilled to become well-rounded, highly skilled, and independent yet deeply collaborative researchers that are needed to solve the problems we face today.

By following this model, students receive extensive training and guidance from academics, their diverse advisory committees, the communities they engage with, specialized departmental courses that are co-developed with Indigenous partners, as well as one another (see *Box 1*). This nested approach is fluid and nonhierarchical, where students find mentors in their supervisor(s) and advisors, instructors, peers, practitioners, and partners to suit different stages of their research process and meet the needs that arise along their learning experience (Fouché and Lunt 2010). This both minimizes risk for students and can help alleviate mentor/mentee power imbalances that might exist or arise (Jones and Brown 2011).

Institution Action 2: Establish functional education and mentorship programs for ECRs in TFR

We discussed the need for better training and mentorship programs to support TFR (see *Barrier 3*). That means that there is a need for institutions to take action to create functional transdisciplinary programs and enable mentors to provide appropriate guidance for ECRs (see *Established Researcher Action 1*). To us, this means retooled curricula to support training that is inherently transformative and geared towards more practical frameworks, providing training that crosses disciplinary and sectoral boundaries, connecting trainees with diverse actors, providing opportunities to learn from a variety knowledge generators, holders, and users (see *Box 2*), and including training on communication techniques that may be outside a classic academic education (see *Goal 4*). We indicated a willingness to play a role in helping to design transdisciplinary programs, but suggest that deans and departmental leaders are responsible for building mechanisms that can enable us to can provide this type of input (Whitmer et al. 2010; Frisk and Larson 2011). In addition to program reform, we discussed the importance of fisheries institutes and institutions having the correct expertise to truly support TFR. For many institutions, this might require targeted hiring efforts or strategic cross-appointments within the institution or community. We also suggest that this will require the creation and funding of mentoring programs for TFR within and beyond academia to reach those without access to such opportunities during their formal university training. Furthermore, to uphold the inclusive framework inherent to TFR there is need to build institutional flexibility to amplify marginalized and minority voices (as discussed by Davies et al. 2021) (see *Barrier 1*). This can be best achieved by enacting supports that enable students from marginalized backgrounds to complete their degrees (e.g., Indigenous students who want to stay in their communities). Although it should be noted that positive discrimination such as this is not a priority (or even legal) in all countries, we discussed examples of institutions making some headway in this area. For instance, at a national and institutional level, South Africa is implementing affirmative action policies such as the Broad Based Black Economic Empowerment that aims to undo past injustices by prioritizing employment to previously disadvantaged groups to find their place at universities. In addition, the National Research Foundation in South Africa prioritizes these and other vulnerable people groups when providing research grants and bursaries, and national fisheries programs are beginning to conform to these criteria (Britz et al. 2015; Weyl et al. 2021). Despite such positive examples, it is important to keep in mind that different contexts will require different enablers to support minoritized groups.

Institution Action 3: Build funding structures that support all parts of TFR

We frequently mentioned the apparent disconnect between what institutions claim to do (i.e., support/encourage TFR) and what they have the capacity to deliver (see *Barrier 1*). We emphasized the need for recognition of the additional labour required to engage in TFR (see *Barrier 2*) that extends beyond 'lip service' and is accounted for in terms of creating funding, incentives, and rewards for such work (but doing so in a manner that protects against shallow attempts at these approaches). A key example was for dedicated funding for knowledge exchange, which may not be considered an eligible research expense in traditional funding schemes and argued for including a co-design phase in funding calls to ensure that a shared vision is developed among all project partners (Nyboer et al. 2021) (see *Barrier 2*). We argue that this is critical for TFR from project development through implementation (see *Box 3*). The same can be said for the interdisciplinary aspects of TFR; the time needed to learn a new discipline or new approaches or to engage with new knowledge structures takes time away from traditional academic outputs. There is a need to formally acknowledge, support, and reward such efforts (Hernández-Aguilera et al. 2021). Funding bodies themselves play critical roles in achieving this suggestion. Funders often claim to support transdisciplinary efforts, but when it comes to the committees that are reviewing work, institutional norms take precedence.

Funders need to critically examine how they solicit and evaluate research funds and rethink who is represented on selection committees (e.g., include non-academics) (Nyboer et al. 2021). Finally, funding for TFR needs to be allocated more equitably and in ways that do not reinforce the usual reward schemes based on publications as the primary measure of impact. Having strategic funding opportunities for the global south or those from racialized or Indigenous communities is essential for realizing what TFR can offer. This is even more important to TFR in some developing countries where funding is limited and tends to adhere to more mainstream approaches. A good example of such funding is the Global Challenges Research Fund- UK Research and Innovation Network that focuses on marine cultural heritage and uses arts and humanities to produce less traditional yet impactful research outputs. Funded projects have produced crafts, music videos, children's books, 3D models, museums, expeditions, cultural festivals, and community boat building associations among other things that promoted their way of life.

BOX 3—ArcticNet as an institution looking to make change

ArcticNet is an example of an institution (although not specifically fisheries focused) that has evolved over time to promote transdisciplinary research and support ECRs in this field. ArcticNet is a research network established in 2003 that supports natural, social, and health science in the Canadian Arctic and stands out from similar networks by turning their transdisciplinary language around synergy, knowledge exchange, training, and communication into concrete actions. For instance, ECRs can access funding to attend training to develop their understanding of Indigenous perspectives and how to engage in ethical research. Inuit ECRs with non-academic backgrounds can apply for dedicated funding that supports community-led research and receive support from regional Inuit advisors who also review research proposals and promote community and Inuit perspectives across the Network. Results are shared with both northern residents who can receive support to attend the annual scientific meeting (ASM) for free, and policymakers through regional summary reports that include ECR results. Such steps from a large institution support and inspire ECRs, and the results of these changes are obvious and visible. For example, the ASM has shifted from a standard scientific conference to one where most posters rely on plain language and visuals to share results. There are line-ups to access the community-based presentation sessions, and a dedicated 'Student Day' features career development panels and research elevator pitches. Everyone from field assistants to Professors Emeritus dance the night away to an Inuk band after the conference banquet.

Institution Action 4: Critically rethink and implement new ways of measuring impact

We discussed how the lack of support for transdisciplinary scholarship from the academic system was connected to the fact the metrics used to measure impact in TFR are flawed (see *Barrier 2*). We suggested that typical academic measures, which focus on simplistic indicators (i.e., published papers), reveal little about the potential or actual impact of research on fish populations, fishing communities, or aquatic ecosystems (see also Hansson and Polk 2018; Cooke et al. 2020). In addition, such metrics do not provide insight into how the research was conducted or the extent to which the findings are or will be embraced by decision-makers, stakeholders, or rights holders (i.e., impact; see *Goal 3*). We suggested that institutions should de-emphasize traditional disciplinary metrics of evaluation and focus on alternative systems to evaluate success amongst ECRs in TFR. Other works have likewise indicated the dire need to develop and implement novel indicators of research impact (e.g., the San Francisco Declaration on Research Assessment (DORA)) (Ravenscroft et al. 2017; Cooke et al. 2020; Fisher et al. 2020). Part of this process could involve adjusting expectations of the types of outputs required from researchers working in transdisciplinary spaces to reflect those that will make change on the ground (see *Barrier 2*). We had several concrete suggestions. First, value engagement in and of itself as a form of impact. This requires defining the type of engagement that is meaningful and could involve assessing the length and quality of relationships and understanding shifts in attitudes amongst partners and institutions over time. Second, value non-academic outputs such as management briefs or knowledge exchange activities with communities on equal ground with academic outputs. Third, fisheries research systems could draw inspiration from other disciplines (i.e., political science) and measure the extent to which publications have translated into policy change. Fourth, institutions could engage in third party assessments of impact (government bodies, fishers, Indigenous communities, consultants, etc.) in a system akin to a typical peer review process (with required funding to make these investments worthwhile on the part of these external bodies). Doing so may require a development of indicators with a shared vision as opposed to spending time catering to a system that is inconsistent with TFR.

Conclusion

In this paper, we synthesize the perspectives and experiences of ECRs from around the world who work (or aim to work) in TFR. Although we acknowledge that TFR is not the only effective approach to fisheries research, it has been shown to be successful at finding solutions to complex and dynamic problems since it is adaptable and responsive to specific challenges in a wide variety of contexts. The findings of our workshop aligned well with outcomes of aseveral recent papers investigating this topic (e.g., Turgeon et al. 2018; Kelly et al. 2019; Andrews et al. 2020; Sellberg et al. 2021). Each of these pieces addressed the common theme that, although TFR is widely acknowledged as critical to bridge science-policy-practice boundaries and to address the 'wicked problems' facing fisheries, support for this work is lacking. There is a disconnect between the expectations placed upon ECRs to be the generation that 'fixes the problem', and the actual support that is provided to do so; this can manifest in declines in mental health with ECRs making serious personal sacrifices in the face of demands to uphold scientific rigour, societal impact, community engagement, and self-care (Sellberg et al. 2021). Barriers to TFR revolve largely around current academic structures, cultures, and metrics of impact that do not uphold or recognize efforts required to support TFR (Singh et al. 2019). Here we suggest several avenues that can and should be enacted now to lower these barriers. A critical finding that bears further recognition is that barriers to achieving these actions are higher in low-to-middle income countries. Researchers already experiencing discrimination for other reasons (e.g., race, gender) will be further disadvantaged. Networks, academic / mentorship support, and funding are especially necessary in the global south where coastal populations are disproportionately more reliant on fisheries for food security and employment (Golden et al. 2016), where fewer research funds are available (Weyl et al. 2021), and where mentorship opportunities are lacking. It is critical that researchers from the high-income countries facilitate redistribution of funds via collaborations and partnerships in LMICs and ensure equitable sharing of benefits including access to resources.

An noteworthy outcome of the COVID-19 pandemic is that the normalization of virtual conferences has allowed for increased inclusivity across various groups (e.g., different income brackets, global north vs. global south, ECR vs. established professional) (Davids et al. 2021). In our workshop this format was powerful. It highlighted that the day-to-day tasks of conducting TFR are profoundly different given various contexts, and that best practices will vary based on the research question, location, groups involved , and team size. On the other hand, the striking similarity and congruence in perspectives highlight the common goals and considerations we share as transdisciplinaryECRs despite our widespread geopolitical experiences. Fisheries science as a discipline has evolved and grown from its historical quantitative and natural science origins toward a broader, holistic, systems-oriented view that embraces both ecological and human dimensions. Here we argue that it is time for all actors in fisheries research to take action to support and uphold the value of these approaches.

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Declarations

Conflict of interest The authors declare no competing interests in the publication of this work.

Data availability No new data were generated for this study.

Appendix A

1. List of countries where workshop participants live and/or conduct research

Continent	Country	Activity
North America	Canada	Live/conduct research
North America	USA	Live/conduct research
North America	Belize	Conduct research
South America	Ecuador	Live/conduct research
South America	Peru	Live/conduct research
South America	Chile	Live/conduct research
South America	Brazil	Live/conduct research
Europe	Norway	Live/conduct research
Europe	Sweden	Live/conduct research
Europe	Denmark	Live/conduct research
Europe	UK	Live/conduct research
Europe	Ireland	Live/conduct research
Europe	Italy	Live/conduct research
Europe	Spain	Live/conduct research
Africa	Uganda	Live/conduct research
Africa	Kenya	Live/conduct research
Africa	Tanzania	Conduct research
Africa	South Africa	Live/conduct research
Africa	Malawi	Conduct research
Asia	Pakistan	Conduct research
Asia	India	Conduct research
Asia	Indonesia	Conduct research
Asia	Philippines	Live/conduct research
Asia	Japan	Live/conduct research
Asia	East Timor	Conduct research
South Pacific	Australia	Live/conduct research

2. Summaries of participants' responses to the online *Google Forms* presented during the workshop.

Discussion Question 1: *Based on your experience as an ECR, what do you believe are key goals for TFR in the future? Think about intellectual challenges and important areas of future research to guide the field and to produce knowledge that is important for sustainable fishery systems.*

- Include transdisciplinary perspectives during all stages of research
  - Engage with diverse stakeholders to understand non-academic needs, concerns, and requirements.
  - Co-design and co-produce studies with all relevant stakeholders, rights holders, and decision makers.
  - Engage with fisheries as socio-ecological systems for a holistic approach to finding solutions.
- Ensure fisheries research is inclusive, relevant, and equitable
  - Consider social context and potential socio-environmental and/or intersectoral conflicts.
  - Addresses inequalities and empower marginalized and/or vulnerable groups.
  - Engage in bias recognition and reduction at both individual and institutional levels.
  - Ensure research itself is not part of the problem (i.e., research does not exclude marginalized voices).
- Ensure fisheries research is impactful, solution oriented, and transformative
  - Implement transdisciplinary fisheries research within management (i.e., government agencies).
  - Build trust with stakeholders and rights holders (example: sign non-disclosure agreements).
  - Paying specific attention to the concrete on-the-ground research impacts; people on the ground should be assessing impact.
- Improve and promote communication between researchers, policy makers, and fisheries managers
  - Include communication with policy/decision makers during postgraduate training.
  - Encourage alternative communication formats (i.e., policy briefs, infographics) that are more targeted for management, practitioners, and policy makers.

Discussion Question 2: ***What are some challenges faced by ECRs working in transdisciplinary settings? How can these barriers be overcome? For each challenge, please identify a possible solution.***

- Institutional inertia and barriers lead to lack of support for transdisciplinary research
  - Facilitate access for ECRs to transdisciplinary mentors.
  - Provide more financial support for ECRs in transdisciplinary research.
  - Improve opportunities for interdisciplinary education at universities and in professional development settings.
- Lack of opportunity for skill development to engage in transdisciplinary research
  - Create more mentoring programs for transdisciplinary research in universities and beyond.
  - Ensure opportunities for ECRs to engage with end-users, policy makers, stakeholders, and rights holders.
  - Provide ECRs training in facilitation and negotiation, interpersonal skills, stakeholder engagement, policy
- Lack of funding opportunities and recognition for transdisciplinary research
  - Incentivize transdisciplinary fisheries research through grants, awards, recognition schemes, job opportunities; but exercise caution around attracting shallow attempts at these approaches.
  - De-emphasize disciplinary metrics of evaluation.
  - Ensure alternative metrics for measuring 'success' amongst ECRs.
  - Acknowledge the extra time required to understand multiple discipline and knowledge structures, and to engage in co-production.
- Lack of transdisciplinary networks for ECRs
  - Encourage networking through transdisciplinary conferences and other activities.

- Share transdisciplinary research opportunities more widely with ECRs.
- Create regional/global collaborative networks that mobilize ECR research and outputs and amplify younger researcher voices.
- Recognizing who can contribute in these settings vs. who doesn't have access; how do we build the network out in equitable ways?

Link to categorized Mural board

https://app.mural.co/invitation/mural/wfc2021ecrworkshop0407/1631924266000?sender=uc9876a0592cbf094c3530448&key=afa22fdc-49d2-43bc-880a-91dfa8012031

Code Book

A.GOALS

1. Embody transdisciplinary approaches during all stages of research

- dismantle traditional disciplinary and institutional silos
- co-create new knowledge
- novel alliances and collaborations

1.1 Engage with fisheries as socio-ecological systems for a holistic approach to finding solutions.

- push to appreciate social science findings
- ensure qualitative data is collected properly
- understand the sociocultural contexts

1.2 Co-design and co-produce studies with all relevant stakeholders, rights holders, and decision makers.

- include bottom-up communication
- encourage new ways of listening
- communication and collaboration
- build trust
- don't make assumptions about what is important to stakeholder

2. Ensure fisheries research is inclusive (legitimate), relevant (salient), credible, and equitable

1.1 Understand non-academic concerns.

- social context
- socio-environmental and/or intersectoral conflicts

1.2 Address inequalities and empower marginalized and/or vulnerable groups

- bias recognition and reduction
- methods used do not exclude marginalized voices
- non-tokenistic

3. Ensure fisheries research is impactful, solution oriented, and transformative

3.1 Define goals through co-development

- collaborative problem identification
- ensure knowledge translation

3.2 Build trust with stakeholders and rights holders

4. Consistently and clearly communicate with policy makers, fisheries managers, governing bodies, communities, and all other relevant stakeholder groups

4.1 Communicate science to the public, to policy makers, managers, stakeholders

4.2 Develop alternative communication formats

- re-envision research outputs
- encourage engagement

B. CHALLENGES/BARRIERS

1. Institutional inertia and barriers

1.1 Academic isolation – don't fit in anywhere

- Bullet Bullet no clear departmental home

1.2 Mismatch between institutional (university) ambition and support

- universities don't have structures in place
- limits on advisory committee makeup
- institutional incentives for fast, low-risk project

1.2 Individualism and individual glory promoted

- PIs and authors on papers must be individuals and not community groups
- difficult to come into community contexts and not seem self-serving

1.3 Disciplinary norms within fisheries

- favours quantitative approaches
- inherent condescension within the academy towards non-academics
- academic innovation of TD approaches questioned

1.4 Lack of funding opportunities (ambition mismatch, like universities)

- difficulties finding grants
- lack of funding allocated for project scoping and communication
- lack of equitable funding for global south vs. global north

1.5 Lack of transdisciplinary networks for ECRs

- lack of support network
- struggles to connect and collaborate
- Lack of recognition for the time and emotional labour

2.1 Longer timescales required to allow for integration and trust relationships with communities

- little support for low-campus-residency models
- Acknowledging the extra time required for funding and degree requirements

2.2 Metrics for valuing TDFR are not oriented in a way that facilitates good process

2.3 Emotional labour and energy required

- Bullet relationship building and conflicts with a community group stakeholder

2.4 Pressure of having to know all disciplines

- Lack of mentorship and few opportunities for development of skills

3.1 Knowledge translation workshop facilitation, community engagement

- communication issues
- communication suggestions

3.2 How to do research with impact; 'best practices' guides not available.

- buzzwords – how to enact them

3.3 Extra work / burden of having to unlearn institutional structures/norm

3.4 Need to self-advocate

4. Other struggles

4.1 Disconnect between expectations felt by ECRs and perceived support

4.2 Mental health in terms of security and job security

- lack of space for ECR voices
- wo*rse for minority groups*

C. HOW TO ACHIEVE GOALS

1. Be self-reflexive and honest in the research process

- honest and transparent about our methods,
- self reflexive
  positionality
- equity and humility
- develop shared languages

.

2. Be open minded and adaptable

- willing to evolve
- accept that you might never reach consensus -
- shift norms within academic systems to transition towards locally led research
- continual feedback and communication at each point.

3. Be solution oriented

- actionable change that can implemented on the ground
- focus stakeholder needs and requirements

- documenting and sharing how we do TDFR
- align goals with longer term projects

4. Communicate in ways that are sensitive across culture and sector

- ask partners how they would like the research to be communicated

D. ACTIONS TO LOWER BARRIERS

1. Build up mentorship network (ECR)

- initiate co-mentorship or peer-mentorship
- networking through conferences
- community mentorship
- develop a best practices guide.
- communicate social processes and methods used in TFR
- Reforming *fisheries education*

2. Be available for good mentorship (Senior)

- facilitate access to transdisciplinary mentors
- create opportunities for ECRs to engage with non-academic partners
- training in facilitation and negotiation
- stakeholder engagement skills

3. Allow junior voices to be heard (Senior)

- we must be problem solvers
- lack of opportunity to make those changes.

4. Be willing to critique academic superiority (institution)

- critique individualism
- not everything is there to be studied
- deconstructing academia is innovation

5. Build functional education and mentorship programs (institution)

- mentoring programs for transdisciplinary research
- improve opportunities for transdisciplinary learning
- reform fisheries education towards more practical frameworks.
- incentivize TD projects
- ensure adequate mentorship.
- build institutional flexibility to amplify marginalized

6. Support all parts of TFR (institution)

- formal recognition of the time it takes
- financial support for ECRs in TFR
- grants, awards, recognition schemes
- financial support for knowledge exchange
- strategic funding opportunities for the global south

7. New ways of measuring impact

- promote, appreciate, value
- de-emphasize disciplinary metrics
- value engagement

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