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Food for Thought

Transdisciplinarity in transformative ocean governance research—reflections of early career researchers

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This paper interrogates the concept of transdisciplinarity, both theoretically and practically, from a perspective of early career researchers (ECRs) in transformative ocean governance research. Aiming to advance research methodologies for future complex sustainability challenges, the paper seeks to illuminate some common uncertainties and challenges surrounding transdisciplinarity from a marine science perspective. Following a literature review on transdisciplinary research, workshops, and a series of surveys, we determine that transdisciplinarity appears to be a concept in search of definition, and that there is a need to explore transdisciplinarity specifically from an ocean research perspective. The paper discusses a number of challenges experienced by ECRs in conducting transdisciplinary research and provides recommendations for both ECRs wishing to undertake more equitable transdisciplinary research and for the UN Decade for Ocean Science to support ECRs in this endeavour (Figure 1). Based on our findings, we interrogate the role of non-academic collaborators in transdisciplinary research and argue that future transdisciplinarity will need to address power imbalances in existing research methods to achieve knowledge *co*-production, as opposed to knowledge integration.

Keywords: early career researchers, knowledge co-production, non-academic collaborators, sustainable development, transdisciplinarity, transformative ocean governance.

Introduction

Transdisciplinarity is a growing expectation of academic research and regarded as an important practice required to reach the United Nations (UN) Sustainable Development Goals (SDGs) (Moallemi *et al.*, 2020). Further, transdisciplinarity is indispensable to the success of the UN Decade of Ocean Science for Sustainable Development, which commenced in 2021 and sets out visions for developing and supporting the "science we need for the ocean we want", to ensure that we develop "transformative" solutions to achieve the 2030 Agenda and "connect ocean science with the needs of society" (UNESCO, 2020) further strengthening the demand for research that stretches beyond a single discipline. However, there is a lack of consensus among researchers regarding the meaning of transdisciplinarity (see Heinzmann *et al.*, 2019), and how its operationalization may be used as a vehicle to meet these global goals (see Jahn *et al.*, 2021).

Against this background, this paper reflects on how transdisciplinarity is understood and applied by early career researchers (ECRs), using the case study project of the United Kingdom Research and Innovation (UKRI) funded One Ocean Hub (OOH). The OOH is an international research programme that is centred around transdisciplinary research for transformative ocean governance. ECRs working as part of, and often outside of, the OOH are tackling societal questions that answer to global calls for sustainability and are classified as "half-scientific and half-societal problems" for which "established" or traditional career paths within a single discipline are "generally not appropriate" (Jaeger-Erben *et al.*, 2018: 384). To answer these questions, ECRs are often required to be "embedded sufficiently in a discipline to know that the discipline is in itself diverse and heterogeneous" (Guimarães *et al.*, 2019: 6), whilst simultaneously comprehending and applying "a large (and far broader) variety of research designs,

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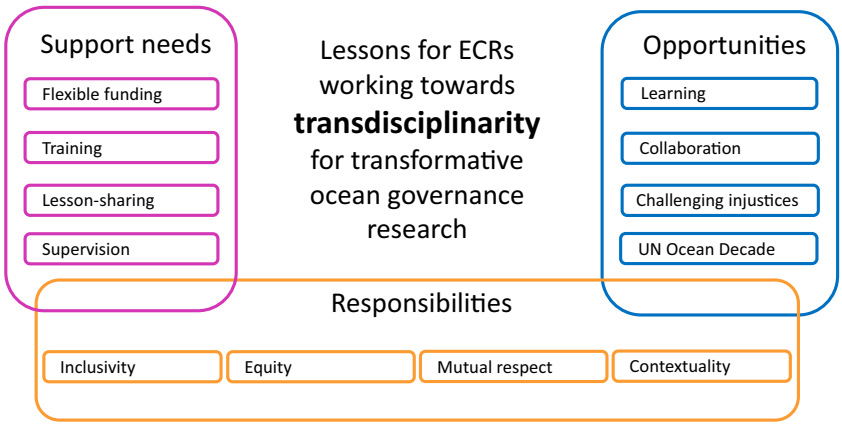

Figure 1. Visual abstract outlining lessons learned for support needed, opportunities and responsibilities of ECRs working towards transdisciplinarity for transformative ocean governance.

theories, and methods" (Ruppert-Winkel *et al.*, 2015: 10). Given the lack of consensus within the research community on transdisciplinarity from conceptualization to application, it can be hypothesized that the research of ECRs can significantly contribute to the evolution and future application of transdisciplinarity.

OOH ECRs present a useful case study given the project's aim of transdisciplinarity and its international scope. Our contribution to the role of transdisciplinary research within ocean research is offered by a diverse group of ECRs who work across three continents, seven different countries, and whose expertise spans several disciplines ranging from fisheries sciences to customary law to creative arts. Although all ECRs have worked across, or with different disciplines in their research, a majority of the ECRs are new to transdisciplinarity.

The OOH is one of several UKRI-funded Hubs aiming to tackle society's most intractable problems. The UKRI stipulated that an interdisciplinary approach to research was required to bring about desired change to these intractable problems, and in response, the OOH indicated in its funding proposal that a transdisciplinary approach was even better suited to achieving its outcomes. Consequently, in its Code of Practice (co-produced by OOH researchers), the OOH developed guidelines for its members which placed transdisciplinarity as a core principle. The OOH's approach is justified by the argument that effective transdisciplinarity can bridge gaps among disciplines, sectors, and stakeholders, which is imperative for integrated ocean management that promotes sustainable human coexistence with ocean ecosystems. Transdisciplinarity in ocean research might differ from other research areas, as the vastness, undelinearity, connectivity, and "commons" of ocean areas often make it difficult to identify, analyse, and engage relevant and impacted stakeholders and rights-holders. Due to these complexities, it is even more important to consider the concept of transdisciplinarity in ocean research to ensure that future transdisciplinary research considers aspects such as equity, history, rights, and transformation.

Our research therefore explores how this transdisciplinary framing is experienced by ECRs working as part of the OOH, both with respect to understanding whether transdisciplinarity is being achieved and how the concept is influencing professional development. Through a series of workshops and surveys we examined areas of consensus and disagreement in how transdisciplinarity is understood in practice. Key areas of disagreement related to the difficulties in achieving transdisciplinarity across diverse disciplines and the need to involve non-academic stakeholders. Additionally, we discuss how this lack of consensus might translate into diverging research practice.

Literature review

A literature review was conducted with the aim of identifying areas of knowledge and scholarship on multidisciplinarity, interdisciplinarity, and transdisciplinarity in ocean governance or environmental sustainability research. Relevant documentation was identified through an online literature review (conducted during July 2021) using the Google Scholar search engine. The search terms "multidisciplinarity"/"multidisciplinary research" OR "interdisciplinarity"/"interdisciplinary research" OR "transdisciplinarity"/"transdisciplinary research" AND "definition"/"ocean governance"/"environmental management" were used. Only peer-reviewed publications in English were considered in our analysis. The titles of the search results were scanned, and documents that referenced the definition of multi-, inter-, and trans-disciplinarity in the context of ocean governance or environmental sustainability research were consequently considered in our review. Searches were considered complete if no new references were identified after the first five pages of search results. Available information was then filtered based on the rankings and impact factor of the scholarship, where highly quoted and ranked scholarship were explored further to develop the definitions of the concepts, as well as to review possible diverging characteristics and understandings as identified through our ECR Workshops.

Defining transdisciplinarity

The focus on alternatives to single discipline research approaches in environmental sustainability research emanates from the recognition that "real-life issues hardly ever match traditional disciplinary approaches" (Uiterkamp and Vlek, 2007: 175). When we explore the meaning of multidisciplinary, interdisciplinary, and transdisciplinary research in the literature, however, we find that there are several different interpretations of the concepts. First, multidisciplinary research can be defined as the coming together of several different disciplines (Uiterkamp and Vlek, 2007), but what this "coming together" means and how "different" the disciplines need to be

is not necessarily clear. One understanding of multidisciplinarity is that a team is made up of different people working independently in their respective disciplines, while another is that a team or single researcher applies research techniques from different disciplines (see Max-Neef, 2005; Uiterkamp and Vlek, 2007).

Interdisciplinary research on the other hand, can be understood as integrating different disciplines to approach a research problem from different angles and schools of thought (Uiterkamp and Vlek, 2007). Instead of different disciplines working independently, interdisciplinarity is the coming together of information, techniques, theories, and perspectives of two or more disciplines. However, there seem to be diverging interpretations as to whether these disciplines need to be closely related, whether the concept is about representatives of several disciplines tackling a single issue (Schipper *et al.*, 2021), or whether a single researcher can conduct interdisciplinary research by combining methodologies common to several disciplines.

Finally, transdisciplinary research can be understood as knowledge production that either *transcends different disciplines* (Max-Neef, 2005; Heinzmann *et al.*, 2019), or that *transcends the disciplines* to work with non-academics (Uiterkamp and Vlek, 2007; Manuel-Navarrete *et al.*, 2021). In their review of 59 sustainability-focused completed research projects, Jahn *et al.* (2021) found a spectrum of different forms of transdisciplinarity among a diversity of research approaches that reveal five different research modes with different approaches and outcomes. Although some of the literature seems to concur that involving non-academic collaborators is necessary for transdisciplinarity, what this inclusion entails, and how to best achieve this in practice remains unclear. Transdisciplinary research may be defined as participatory research to "process a socially relevant issue" (Pohl, 2010) or as a "reflexive research approach that addresses societal problems by means of interdisciplinary collaboration as well as the collaboration between researchers and extra-scientific actors" (Jahn *et al.*, 2012: 4). The thought that interdisciplinarity is a precondition of transdisciplinarity may be contentious, and different approaches to research methods will either focus on integrating knowledge from outside academia or co-producing knowledge between academic and non-academic actors (Jahn *et al.*, 2021). These diverging conceptualizations of transdisciplinarity provide further challenges in research practice for ECRs aiming to contribute to sustainable transformative ocean governance. A table showing several different definitions of multidisciplinary, interdisciplinary, and transdisciplinary research is included below (Table 1).

In this paper, we rely on Bernstein's (2015: 1) description of transdisciplinarity as being characterized by "its focus on 'wicked problems' that need creative solutions, its reliance on stakeholder involvement, and engaged, socially responsible science".

Expectations of ECRs when conducting transdisciplinary research

As the world grapples with social-ecological challenges often termed wicked (see Bernstein, 2015; Chuenpagdee, 2019) in nature for their lack of one clear solution or even understanding, there is a cumulative need for research, that surpasses academic institutions (Benham and Daniell, 2016) and fully incorporates transdisciplinarity to involve non-academic collaborators for lasting impact (Rivers *et al.*, 2022). (In this paper, we refer to "collaborators" instead of "stakeholders" or "partners" to emphasize the role of collaboration and co-production of knowledge in transdisciplinary research practices. We argue that for transdisciplinarity to be challenging inherent power dynamics in research, where the "academic researcher" may hold power over the "research participant", people outside academia who are involved in the research should be acknowledged as collaborators.) In recent years, transdisciplinary research approaches have been applied in several social-ecological projects (see Galafassi *et al.*, 2018; Heinzmann *et al.*, 2019; Barnes *et al.*, 2021), and researchers have found them to be effective in finding solutions to "real-world problems" (Russell *et al.*, 2008:461) and promoting justice (Schreiber *et al.*, 2022). Transdisciplinarity can have a broad range of benefits and has the potential to widen research perspectives as it emphasizes collaborative work and knowledge co-creation (Jahn *et al.*, 2012; Strand *et al.*, 2022a).

Transdisciplinarity brings together researchers and collaborators from different disciplines, backgrounds, and knowledge systems, allowing them to work together in finding solutions to intricate challenges. The diversity of researchers and collaborators means that they can break boundaries and excel outside the norm of their disciplines by generating new knowledge, learning from each other, and creating impact (Gehlert *et al.*, 2010). A transdisciplinary approach further helps achieve adaptability and inclusivity, which are some of the key principles of transformative ocean governance (see Rudolph *et al.*, 2020; Erinosho *et al.*, 2022). By adaptability, the authors refer to adaptive governance that enables learning, experimentation, reflexivity, and monitoring by depending on continuous feedback loops from the environment and between different organizational levels (Cooper and Wheeler, 2015).

Transdisciplinary research aspires to be very versatile and many researchers, especially ECRs, struggle with balancing its demanding requirements (Sellberg *et al.*, 2021). Conducting effective transdisciplinary research requires a great breadth of skills and resources, which may mean that it is beyond the reach of smaller projects with limited funding and resources. Jaeger-Erben *et al.* (2018) suggest that ECRs should go through capacity-building training to gain skills necessary to carry out transdisciplinary research effectively. These skills include reflexivity to assess one's own biases and positionalities in the research group; science communication to facilitate a two-way process of information; reflection to manage expectations of the research group; and moderation to facilitate the coming together of different epistemologies (see Jaeger-Erben *et al.*, 2018). Yet, Sellberg *et al.* (2021) point out that existing academic institutions do not readily support transdisciplinary research, which adds to challenges for ECRs to accrue the necessary skills and experience. There are still many debates concerning the definition and practice of transdisciplinary research. However, in summary, transdisciplinary approaches encompass effective methods and resources that support influential work within societies and on complex topics, such as ocean governance.

Oceans governance is recognized as an intractable issue of significance to global society, and transformative ocean governance is needed to address historic failures of visions of equitable sustainability. Transformative ocean governance can be understood as a move towards more inclusive and integrative

Table 1. Different definitions of multidisciplinary, interdisciplinary, and transdisciplinary research.

Research approaches	Different definitions drawn from several scholarly works				
Multidisciplinary research	"a particular (policy) problem or an (other) observable phenomenon is considered from different disciplinary viewpoints" (Uiterkamp and Vlek 2007).	"involve collaboration between researchers working within different disciplines" (Benham and Daniell, 2016).	"researchers work in parallel or sequentially from their disciplinary-specific base to address a common problem" (Heinzmann *et al.*, 2019).	"non-integrating engagement of two or more disciplines" (Barnes *et al.*, 2021).	"integrating the results from different disciplines" (Janssen and Goldsworthy, 1996).
Interdisciplinary research	"relevant parts (concepts, models, methods, findings) of different scientific disciplines are merged together and neatly integrated" (Uiterkamp and Vlek, 2007).	"'involve collaboration (…) on areas of overlap between disciplines" (Benham and Daniell, 2016). "the collective efforts to tackle a single issue from multiple disciplinary perspectives" (Schipper *et al.*, 2021).	"researchers work jointly but still from a disciplinary-specific basis to address a common problem" (Heinzmann *et al.*, 2019).	"think and work across disciplines" (Deininger *et al.*, 2021). "research drawing on two or more disciplines with some unifying thinking" (Barnes *et al.*, 2021).	"Different academic disciplines working together to integrate disciplinary knowledge and methods, to develop and meet shared research goals achieving a real synthesis of approaches" (Kelly *et al.*, 2019).
Transdisciplinary research	"the crossing of boundaries between scientific and nonscientific communities" (Uiterkamp and Vlek, 2007). a process of joint knowledge production characterized by the inclusion of scientific and non-scientific perspectives and real-world practice (Schreiber *et al.*, 2022)	"focus on transcending [academic] disciplines and engagement with external stakeholders" (Benham and Daniell, 2016). "knowledge co-production with non-academics" (Manuel-Navarrete *et al.*, 2021).	"researchers work jointly using shared conceptual framework that draws together disciplinary-specific theories, concepts, and approaches to address a common problem" (Heinzmann *et al.*, 2019).	"working across knowledges (Nicolescu, 2008) evolving to break down disciplinary barriers to understand and merge diverse perspectives (Bernstein, 2015)" (Barnes *et al.*, 2021).	"co-learning across scientific disciplines to better incorporate (potentially divergent) stakeholder views and values" (Moallemi *et al.*, 2020).

decision-making for ocean biodiversity (Visseren-Hamakers *et al.*, 2021; Erinosho *et al.*, 2022), where this paper also recognizes the importance of shifting power dynamics between sectors and actors in ocean governance more broadly to emphasize its role in blue economy priorities and improving human wellbeing (Rudolph *et al.*, 2020). It is also important to note the growing importance and recognition for transformative ocean governance as it is identified as fundamental to achieve the SDGs and called for by both the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) and the Intergovernmental Panel on Climate Change (IPCC)—the two bodies tasked with bridging the science-policy interface for the wicked problems of climate change, biodiversity, and ecosystem service loss. This is significant as the IPBES and IPCC are both intergovernmental bodies which have a high membership among Member States (140 and 195 respectively) which indicates widespread acceptance for their support and assessment of biodiversity, ecosystem, and climate change science.

In preparation for future research vital for required sustainability transitions, we argue from our analysis that ECRs should ready themselves to take on transdisciplinary research, which include the following:

(1) addressing complex, multi-faceted challenges and creating impact;

(2) building relationships and engaging with collaborators outside of academia;

(3) being flexible, adaptive, and inclusive.

Methods

The study takes on a sequential mixed methods approach, using two questionnaires to understand the broad themes of agreement and disagreement, where the main findings of each questionnaire inform the two workshops' topic discussions (see Leavy, 2017: 19). This approach was preceded, supported, and followed by a literature review on transdisciplinarity in ocean governance research. The aim of this study was originally to identify consensus amongst topics relating to transdisciplinary research and transformative ocean governance through a Delphi exercise, but the first survey and workshop identified the need to further explore the concept of transdisciplinarity amongst diverse disciplines, backgrounds, ontologies (worldviews of being), epistemologies (worldviews of knowing and understanding), and axiologies (worldviews of values).

Study participants were recruited through the OOH Early Career Network mailing list and invited to attend two virtual workshops taking place on 23rd and 27th August 2021 and fill in two pre-workshop questionnaires. A total of 14

participants participated in the workshops, who were based in seven different countries and conducted research within several academic disciplines including social sciences, natural sciences, and law. All participants self-identified as ECRs and are members of the OOH programme. All workshop participants are co-authors of this manuscript.

Surveys

This study utilized survey design methods prior to the two virtual workshops. The two surveys were conducted using online questionnaire software (Qualtrics, Provo, UT) and included both quantitative and qualitative questions. All data was anonymized.

The first questionnaire consisted of 12 questions, four quantitative multiple-choice questions aimed at identifying participants' disciplines, institutions, and research location, whilst the eight qualitative open-ended questions were aimed at exploring different ways of conceptualizing transdisciplinarity and transformative ocean governance. Specifically, questions focused on how ECRs define transdisciplinarity, whether they consider their work to be transdisciplinary, what they experience or foresee as the main challenges of conducting transdisciplinary research, and what transformative ocean governance means to them.

The design of the first questionnaire was influenced by the study aim of identifying consensus amongst topics relating to transdisciplinary research and transformative ocean governance (Supplementary Appendix S1). The second questionnaire consisted of seven questions, two of which have both a multiple-choice and open-ended question component (Supplementary Appendix S1). These questions focused on the definition and main characteristics of transdisciplinarity. The second questionnaire posed follow-up questions emerging from the first questionnaire and workshop, and centred on participants' reflections from the first workshop, whether their understanding of transdisciplinary has changed and the role of stakeholder engagement in transdisciplinary research. The responses to both questionnaires were analysed by three of the authors before the workshops and used to inform the discussion points during the workshops.

Workshops

Two virtual workshops were held to further discuss and elaborate on the main topics arising from the questionnaires.

The first workshop started with an introduction of the workshop aims, a short presentation by Elisa Morgera (OOH project director) on her understanding of multi-, inter-, and transdisciplinary research and a summary of the results from the first survey. Participants were then assigned to one of three breakout groups, which were hosted by three of the authors/workshop organizers. The first workshop facilitated discussions around two central questions: (i) whether it matters that we are not in consensus about the meaning of transdisciplinarity, and (ii) why transdisciplinarity is important for transformative ocean governance. The discussion questions arose from the results of the first questionnaire; but it must be noted that these are known questions in the transdisciplinary literature and have also been discussed within the OOH (Wahome *et al.*, 2020). Additional queries that arose from the discussions were the usefulness of transdisciplinary research, barriers to undertaking transdisciplinary work, and what transformative ocean governance looks like to the different participants.

The second workshop started with a reflection on the results from the second questionnaire by three of the authors and was followed by a group discussion on what transdisciplinarity means and entails, the importance of involving stakeholders in transdisciplinary research, but also on the lack of clarity on how best do transdisciplinary research in practice. Participants were then assigned to one of two breakout groups to discuss (i) whether ECRs find the concept of transdisciplinarity helpful in developing their careers and research, and (ii) problematizing whether transdisciplinarity is achievable or if it is perpetually strived towards. A plenary session was held after the breakout discussions in both workshops to share information.

Mural

Mural (https://app.mural.co/) is an online tool that allows multiple contributors to share their ideas, thoughts, and opinions using simulated "post-it" notes on an online whiteboard. Participants can access the Mural whiteboard by signing in either with their own names or anonymously. In this study, we encouraged the use of Mural during and after the workshops to ensure everyone had the opportunity to share their thoughts and ideas, to open up the space for participants who wanted to air their opinions anonymously or those who did not feel comfortable sharing their opinions during the live workshops. The whiteboard was organized according to the workshop structure and discussion topics and included an open platform to share any insights or concerns about the workshops themselves.

The questionnaire results, workshop recordings and chat transcript, and mural boards were made available to all participants. Information was collated by one of the authors and grouped into five broad themes such as points of agreement and disagreement, challenges of transdisciplinarity, stakeholders as collaborators, and the continuum of transdisciplinarity. Survey questions were then grouped under one of these five themes (Supplementary Appendix S1). All workshop participants summarized the available information following the structure listed in Supplementary Appendix S1 and are authors in this publication.

Results

This study engages five post-doctoral researchers and nine doctoral candidates conducting research in Ghana, Namibia, Papua New Guinea, Portugal, Solomon Islands, South Africa, Barbados and the Wider Caribbean, the UK, Vanuatu, and in areas beyond national jurisdiction (ABNJ). Although many work interdisciplinary or across multiple disciplines (see Table 2), the authors can be grouped based on their backgrounds as follows: six from the natural sciences, five from the humanities and social sciences, and three from the legal sciences.

Characteristics of transdisciplinarity

The survey results and workshop discussions built consensus on certain requirements for successful transdisciplinarity in transformative ocean governance research. At the time of data collection, participants' engagement in transdisciplinary

Table 2. ECRs identifying with different themes, faculties, and disciplines.

↓Themes/→Faculties	Natural sciences	Social sciences and humanities	Law
Anthropology		I	
Climate change	III	IIII	
Creative arts		III	
Cultural heritage		IIII	
Customary rights		II	
(De)colonial studies		III	
Development studies		III	
Ecosystem modelling	II		
Ecosystem services and natural capital	II	I	
Environmental rights		I	I
Fisheries	IIII	I	II
Human rights		I	I
International ocean governance		I	I
Marine policy and management	IIII	III	
Marine ecology and biodiversity	V	II	
Other marine human activities and impacts	I	II	
Technology	I	II	

research varied across the group. Some researchers had been involved in transdisciplinary research; however, the majority of participants had not. The first survey asked what transdisciplinarity meant to participants, whilst the second survey asked them to rank different characteristics of transdisciplinarity that had emerged from the first survey. A willingness to learn (67%), respect (50%), collaboration (50%), and trust (33%) were the four characteristics that ranked highest in that exercise (see Figure 2). As was highlighted by one of the participants, and supports the survey results: "without respect, collaboration and compromise any collaborative research endeavour, including transdisciplinarity, is bound to fall short of its aims".

An important understanding and point of discussion that emerged from the workshop was that truth does not necessarily reside within academia and that knowledge is produced outside of academic institutions every day. Building on this recognition, the ECRs agreed about the need to engage non-academic collaborators in transdisciplinary research, although people had different ideas of what this looks like in practice (see the section "Involving non-academic collaborators as a moral obligation: insights from international law"). Another consensus emerging from the workshops was that transdisciplinarity should mean collaborative knowledge co-production and that transdisciplinarity is a requirement for transformative ocean governance. One participant highlighted that their main takeaway from the first workshop was that "while transdisciplinarity has the potential to become overwhelmingly complex, it seems to present an opportunity to rectify past injustices and ensure that ocean governance moving forward is sustainable, equitable and just". The impact of single-discipline and discipline-specialized research may often be limited due to "shallow" approaches that do not "go deeply or broadly enough into the fundamental determinants of problems" (Neuhauser, 2018: 26). Transdisciplinary research, on the other hand, can cross the disciplinary silos and develop an inclusive approach to knowledge co-production. The shared learning experience of transdisciplinarity can help researchers overcome barriers to "imagining new worlds and ways of being" and is especially pertinent in dealing with the connectivity in complex social-ecological systems (see Biggs *et al.*, 2021).

Following several discussions and reconceptualizations of a possible definition of transdisciplinarity, the closest the group of ECRs came to consensus was:

Transdisciplinarity is a collaborative research process between researchers and the individuals the research is supposed to engage, benefit, or consider, together developing a co-designed knowledge generation process.

This definition complements the UN Decade of Ocean Science focus on "the science we need for the ocean we want", emphasizing the need to "co-design new research strategies with ocean stakeholders" to achieve "transformative ocean science solutions for sustainable development, connecting people and our ocean" (UNESCO, 2020). Problematizing the focus of one "science", however, the ECRs also agree that a challenge of transdisciplinary research is the coming together of different disciplinary "languages", methodologies, ontologies, epistemologies, and axiologies. As highlighted by participants, differences in "jargon" or terminologies, applications of research methods, and views of what constitutes sufficient evidence, relevant information, or valid knowledge can pose significant challenges to conducting transdisciplinary research. Coherent arguments are difficult to construct if the research team struggles to agree on what is important, who the knowledge is produced for, and what knowledge is of value.

Challenges in transdisciplinary research

Before attending the workshop, participants were asked to describe foreseeable challenges in conducting transdisciplinary research. One of the common views was that the pursuit of transdisciplinarity can be very time-consuming as you need to facilitate the coming together of different values, viewpoints, and realities of collaborators. Another challenge was that different languages and discipline-specific jargon could lead to misunderstandings of the problem and exclusion or omission of certain knowledge forms, where powerful actors, prominent narratives, or dominating cultures might subjugate others. A view that emerged from discussions was that

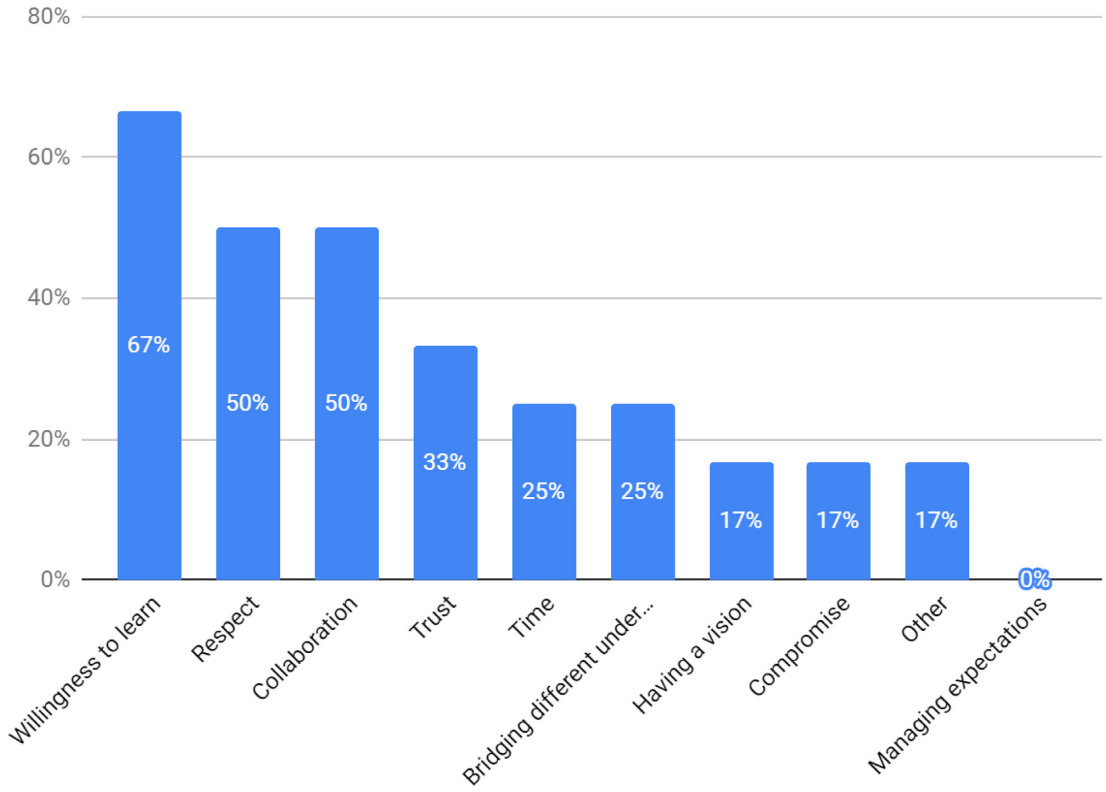

Figure 2. Graph showing the % of participants that ranked each term as one of their three most important qualities of effective transdisciplinary research.

transdisciplinary research requires dedicated investment of time, effort, and funds and that values and expectations within an inclusive research team would require effective exploration and communication early in the project.

During discussions, the group identified a number of theoretical and practical challenges (see Figure 3) when conducting transdisciplinary research, particularly as ECRs. Of the former, the dominance of institutionalized disciplinary epistemologies was highlighted, and that this can create a barrier for "knowledge dialogue" and "connection and integration across and beyond disciplinary boundaries" (Guimarãesa *et al.*, 2019: 13). In order to promote mutual learning and present solutions to cross-cutting communal crises, we agreed that there is an "urgent need to widen and change, both the production of knowledge and its organization, not least, in order to be able to understand and address the future and its challenges" (Guimarãesa *et al.*, 2019: 1). To robustly address these challenges requires a far greater breadth of training than could be reasonably achieved by a single person. To conduct effective transdisciplinary research, collaborators should come prepared to both share and receive knowledge and experiences.

Time and funding were highlighted as practical constraints to achieving transdisciplinary research. Recognizing that transdisciplinary research habitually involves large numbers of diverse collaborators, time is required to build meaningful relationships and shared understanding. The multiplicity of actors involved in transdisciplinary research follow their "own formal and informal rules and … own value system[s]" (Jaeger-Erben *et al.*, 2018: 384), thus ECRs must navigate complex relational networks, and assume multiple roles (Jaeger-Erben *et al.*, 2018: 382) to ensure partnerships are built on principles of integrity, trust, and mutuality. Suggestions to achieve this include developing and redeveloping research objectives, data collection methods, and analysis approaches with co-researchers from the initiation of the project and throughout its lifetime and establishing expectations from and between different collaborators' roles when it comes to facilitation, communication, management, and inputs through reflexive workshops (see Strand *et al.*, 2022b). With this in mind, there was a common argument among the ECRs that current funding opportunities tend not to incentivize and support transdisciplinary research and supervision (Jahn *et al.*, 2012: 1, Nyboer *et al.*, 2022). At present, many funding mechanisms lack the flexibility required to successfully respond to the demands of transdisciplinary research (Nyboer *et al.*, 2022). Partnerships with non-academic collaborators are routinely deemed ineligible for funding (Jaeger-Erben *et al.*, 2018: 384), while distribution of funds to third sector parties is restricted or prohibited. As funders "become more prescriptive in identifying research priorities and desired outcomes" (Cundill *et al.*, 2019: 2) the iterative methodology of transdisciplinary research, essential for equitable participation and representation, is marginalized and diminished. This is detrimental to the future of transformative ocean governance, where one of the core aims is to shift and challenge current power imbalances.

Conflicting understandings across disciplines

The survey results and workshop discussions revealed differing perspectives on a number of topics related to transdisciplinarity and transformative ocean governance. A lack of consensus on relevant definitions, persisting even after the workshop discussions, highlighted the challenge of developing shared understanding across different disciplines, sectors,

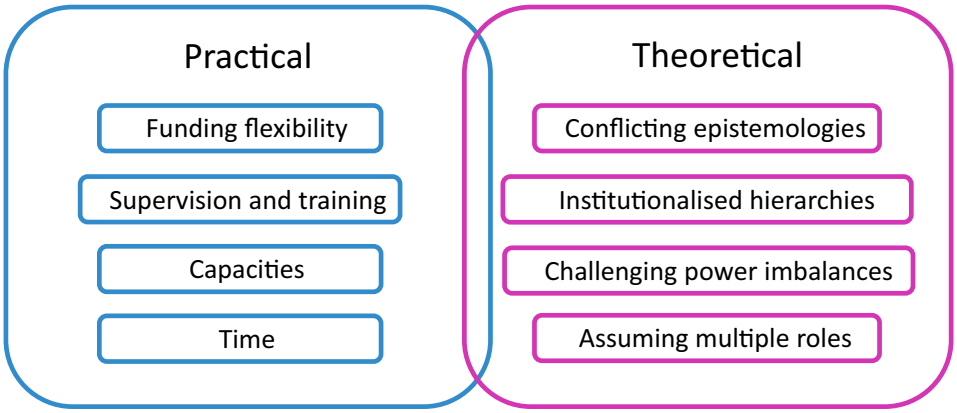

Figure 3. Summarizing some of the most prominent practical and theoretical challenges to transdisciplinary research amongst ECRs in transformative ocean governance research.

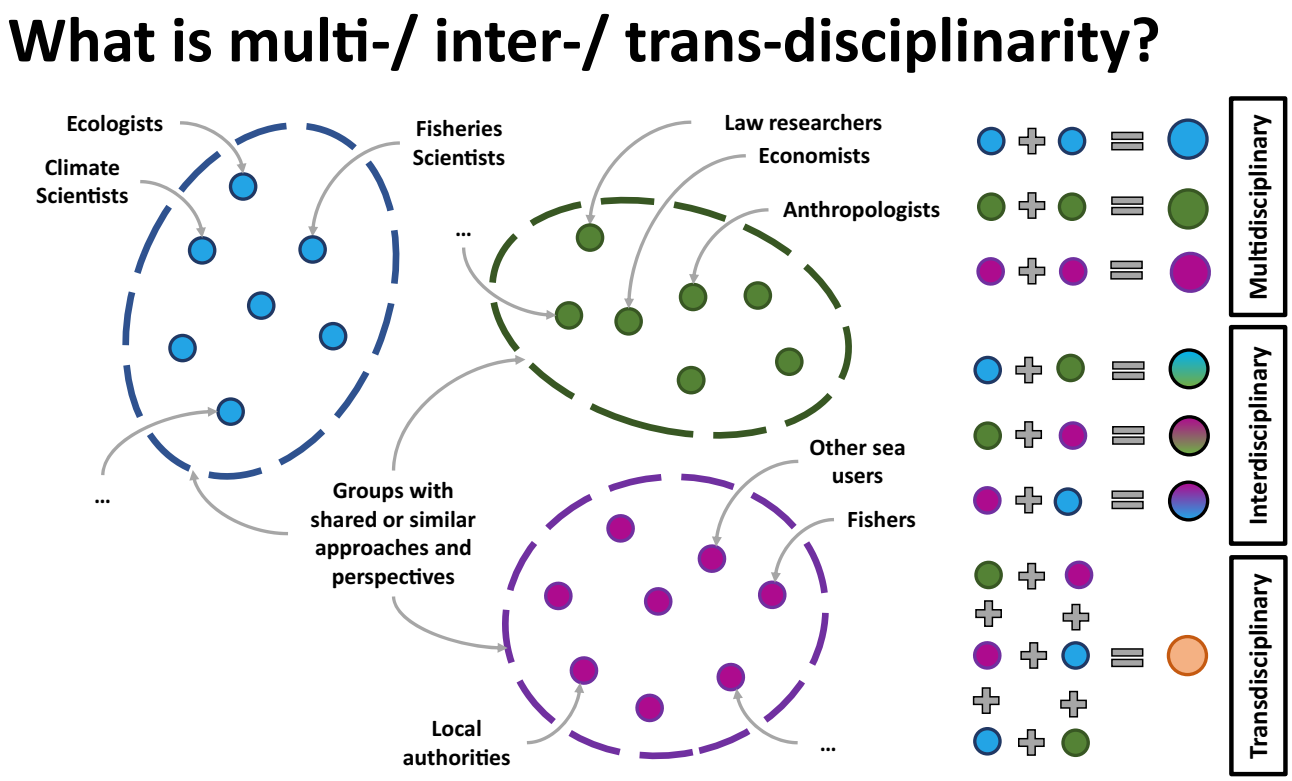

Figure 4. A figure prepared by a group of the ECR participants to summarize key differences between multidisciplinary, interdisciplinary, and transdisciplinary research after their workshop discussions, where an understanding of multidisciplinary research is when disciplines are closely related or with similar approaches or perspectives.

and perspectives. What does and does not constitute transdisciplinary research was debated in the following ways.

A need for "related" disciplines?

The group of ECRs agreed that multidisciplinary ocean governance research is knowledge production *involving multiple disciplines*. An example is a team made up of a marine biologist, a sociologist, and an economist exploring the different environmental, social, and economic challenges to managing a particular stretch of ocean. Interdisciplinary ocean governance research can be simplified to mean knowledge production that brings together researchers working *across multiple disciplines* such as environmental and social sciences, aiming to better understand complex marine systems. Debate among the ECRs arose on whether these disciplines need to be closely "related" or not and whether the researchers needed to have similar perspectives and approaches to knowledge production (seeFigures 4 and 5).

Stakeholder engagement on a continuum?

Transdisciplinary ocean governance research may be termed as knowledge co-production that *transcends the disciplines* to work with non-academic collaborators. An example might be a mix of academic researchers working together with

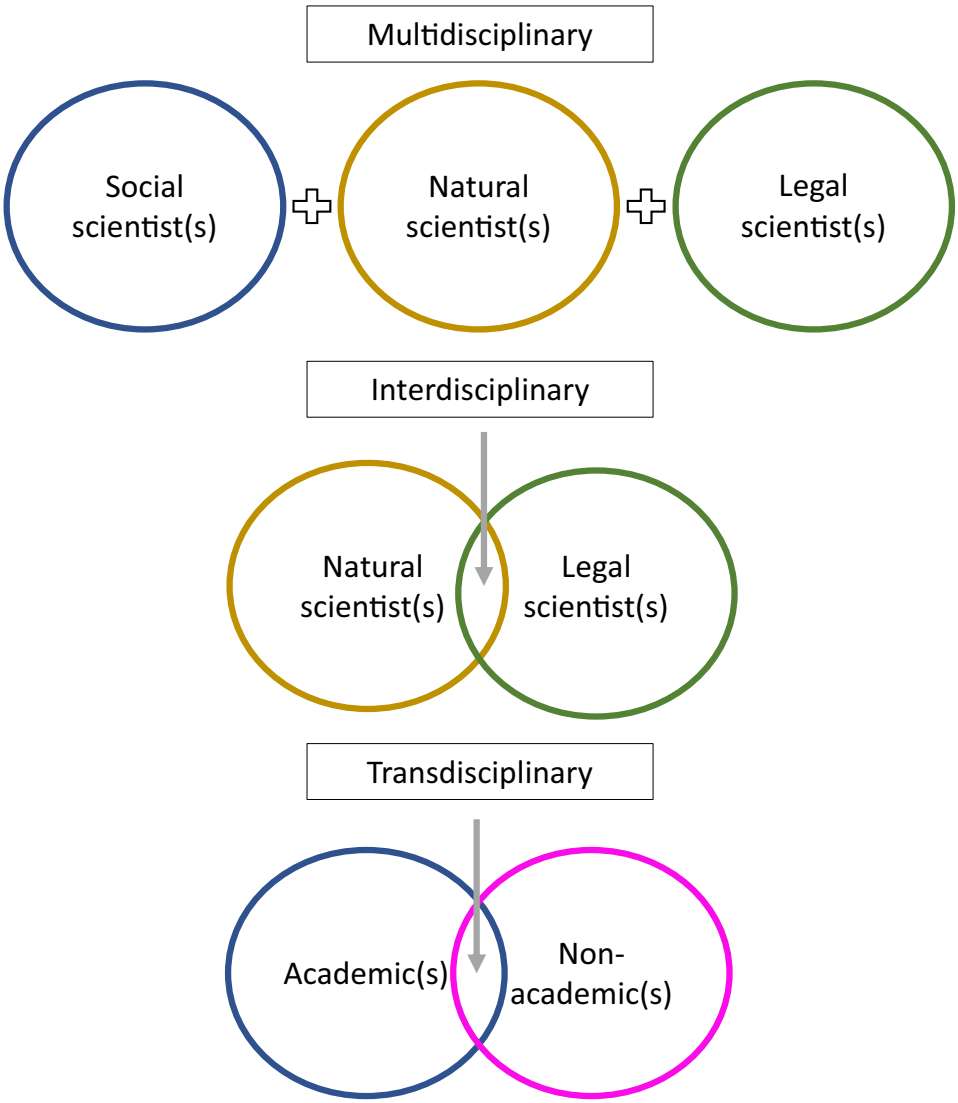

Figure 5. Another figure prepared by a group of the ECR participants to summarize key differences between multidisciplinary, interdisciplinary, and transdisciplinary research after their workshop discussions, where the main difference between multidisciplinary and interdisciplinary research is the "integration" of different disciplines, whilst transdisciplinary is the collaboration between academic and non-academic actors.

local communities to co-produce knowledge on how area-based ocean management approaches can better represent the needs of the surrounding communities. Examples in the OOH include public storytelling approaches and research-based theatre plays to increase participation in ocean governance (see Erwin, 2021; Lalela uLwandle, https://www.empatheatre.com/lalela-ulwandle), and social scientists who engage with local communities or traditional knowledge holders to co-produce knowledge for more inclusive ocean governance (see McDonald, 2021; Strand *et al.*, 2022a). Although the ECRs agreed that transdisciplinary research needs to involve non-academic collaborators, the characteristics and degree of this involvement remain contentious and prompted consideration of a continuum of transdisciplinarity. This is further considered below.

Stakeholders as collaborators

The second survey indicated that most participants considered stakeholder involvement critical to transdisciplinary transformative ocean governance. The degree to which non-academic actors must be involved, and characterized, was uncertain. The term "stakeholder" was questioned: some participants featlt that non-academic participants in the research process should be referred to as "collaborators" or "partners", rather than "stakeholders", as the latter term might be "othering" and belittle their contribution to the research process. Different perspectives on the meaning of "stakeholders" were evident, which by most definitions may imply an active participant with influence and agency but which may frequently be treated as disengaged bystanders or a resource to enable the ticking of participatory boxes. Discussions also centred on non-academic stakeholders as marginalized groups or peoples, as opposed to policy-makers or influencers (such as consultants or UN bodies), raising questions around biases in the understanding of stakeholders in transdisciplinary research and a need for clarity and a definition. Due to the commonly perceived failure of "stakeholder engagement", a suggestion was made that transdisciplinarity requires a shift beyond "engagement" and into "stakeholder involvement" for knowledge co-production.

The continuum of transdisciplinarity

One of the questions raised in discussion was whether we "do transdisciplinarity" or "work towards transdisciplinarity", acknowledging the challenge of achieving transdisciplinary work, but also the difficulty in identifying a clear boundary on the continuum between multi- and transdisciplinary research. The stages of increasingly integrative and collaborative ways of working likely lie on some sort of continuum, where the two ends of the spectrum may be made up of (1) specialized research in a single discipline, and (2) "strong transdisciplinary" (Max-Neef, 2005) incorporating stakeholder involvement throughout the process, knowledge co-production, exploration of different knowledge systems, and attention to power (im)balances (Figure 6). "Doing transdisciplinarity" would therefore be the claim of conducting "strong transdisciplinarity", which transcends the disciplines and ensures that non-academic collaborators take an integral and equitable part in the knowledge production process. "Working towards transdisciplinarity" is a mindset of aspiring towards achieving the former, rather than claiming achievement of it, and would be somewhere on the below continuum between interdisciplinarity and transdisciplinarity.

In the second survey, participants were asked where on the continuum they felt their current research efforts fell. The majority of respondents indicated they were not yet practising transdisciplinarity or were at initial stages of incorporating transdisciplinarity into their work. In contrast, in the first survey (prior to workshop discussions), 60% of participants indicated that they considered their work to be (at least partially) transdisciplinary, which may point to a growing understanding of what transdisciplinarity represents during workshop discussions and the need for transdisciplinary training amongst ECRs.

Some participants pointed out that while their work focus may not be inter- or transdisciplinary, participation in the transdisciplinary OOH project, their work could contribute to achieving transdisciplinarity and solving complex issues. There was a common feeling among the participants in the middle of the continuum that they were working to add elements of transdisciplinarity into their research, for example, working with stakeholders outside academia to inform the research process. However, ECRs also raised the point that opportunities for emerging researchers to participate in transdisciplinary work were few and usually related to specific projects, rather than being a feature of their day-to-day work experiences. ECRs, in particular, often work for specific projects under short timelines with limited resources, and frequently lack the autonomy to develop their own projects and transdisciplinary skills outside their work expectations (Deininger *et al.*, 2021).

Discussion

The discussion considers (i) whether the involvement of non-academic collaborators from a legal perspective can bring clarity to best practices; (ii) the extent to which specific applications of transdisciplinarity can challenge existing asymmetrical (and colonial) power relations between different knowledge holders; and (iii) whether it matters if researchers and research institutions have different conceptualizations of transdisciplinarity.

Involving non-academic collaborators as a moral obligation: insights from international law

Transdisciplinarity combines "societal with scientific problems" (Jahn *et al.*, 2012) and through self-reflection aims to impact both society and research studies. Researchers working in transdisciplinary settings are expected to actively engage and collaborate with community stakeholders through methods that support equitable co-creation of knowledge and solutions. These methods and approaches are required to foster consideration and respect for diverse ontologies, epistemologies, axiologies, perspectives, and interests that embed principles of equity at all stages of research (Pohl *et al.*, 2008). Transdisciplinary researchers play an important role in meeting the demands of equitable research and embedding methods that support mutual learning prospects that empower researchers and collaborators alike to transcend and assume a dedication to shared knowledge (Winschiers-Theophilus *et al.*, 2012). Recognition that the act of research and knowledge creation itself has impact is essential to avert parachute science, manipulation, and other untrustworthy research practices, where benefit distribution is not deliberated (Maasz *et al.*, 2018).

The principle of public participation, as set out in international environmental law, enables members of the public to get involved in decisions that affect the environment (Bekhoven, 2016). This principle is recognized in a multiplicity of binding and non-binding instruments (for example, the 2001 Aarhus Convention and 2018 Escazú Agreement). The right to participate in governance is also widely recognized as a human right (see for example, Article 13 of the 1981 African Charter on Human and Peoples' Rights). International judicial bodies have been instrumental in giving substance to this norm, and we can draw some insight from their jurisprudence to reflect in our participatory processes.

While the details and forms of participation should be designed to suit each situation, public consultation is not a single act but a process of dialogue and negotiation that requires good faith from all parties involved and the desire to reach a mutual agreement (Duvic-Paoli, 2012: 88). This point aligns with the characteristics of effective transdisciplinary research ranked by the ECRs (Figure 2, see the section "Characteristics of transdisciplinarity"). Another important aspect is that the consultation process must be meaningful. Three criteria to determine meaningful consultation have been identified in international law, namely (i) prior consultation during the early stages of the development and planning of the proposed measures; (ii) several meetings and interviews with various stakeholders, and; (iii) the possibility for the public to submit documents and comments [see, for example, the 2010 Pulp Mills on the Uruguay River (*Argentina v. Uruguay*) Judgement]. Although these criteria are directed at States and their consultation of relevant stakeholders or citizens in decision-making processes, they help guide how non-academic collaborators should be engaged in transdisciplinary research.

First, collaboration with stakeholders should ideally take place from the early stages to ensure all participants have a say in the conceptualization and planning of the research. Second, researchers should strive to engage with non-academic collaborators in multiple ways. Regardless of the avenue or degree of involvement, it is argued that a founding principle should be the support of non-academic collaborators to effectively

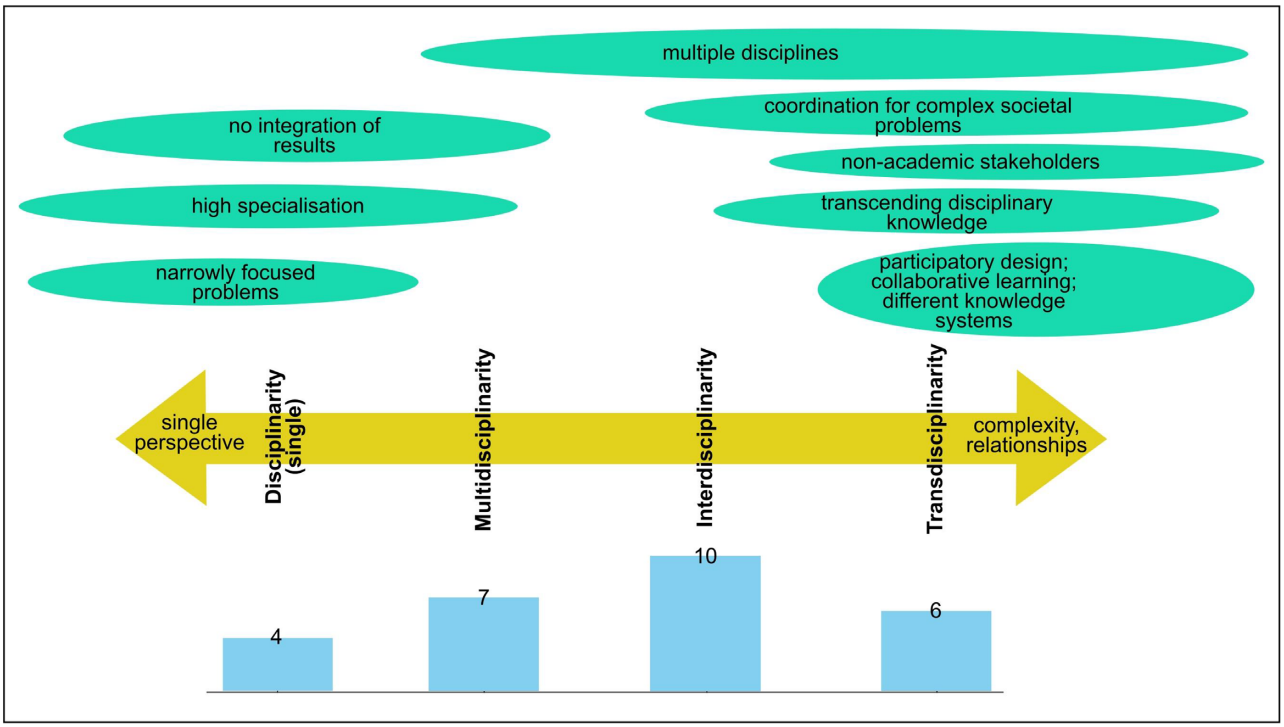

Figure 6. A schematic of the disciplinary approaches existing on a spectrum, showing the number of ECR respondents, to the second survey, who felt their current work straddled the various disciplinary categories.

contribute their perspective or knowledge to the transdisciplinary research.

Although researchers frequently have no legal duty to engage non-academic participants in their research, there is a moral and ethical obligation to engage non-academic collaborators that can ensure the research reflects the lived experiences of affected communities [See international guidance on the need to create laws to respectfully engage with Indigenous and local knowledge holders in the Convention on Biological Diversity, Article 8(j) (2016)]. Participation in decision-making processes on environmental issues implies that people (individuals or groups) have the opportunity to share their views and interests in making decisions that have or may have an impact on the environment (Bekhoven, 2016). Participation of non-academic partners will tend to strengthen appropriate representation of societal problems within research. Furthermore, their collaboration can contribute relevant experiential knowledge, based on common sense and personal experience, as well as value-based knowledge, both of which may increase the quality of transdisciplinary research (Glucker *et al.*, 2013: 107).

Empowering ECRs in transdisciplinarity and transformative ocean governance

Most ECRs agreed that conducting transdisciplinary research is challenging, particularly integrating different disciplinary "languages", methodologies, ontologies, and epistemologies. Reflecting on these challenges, a "willingness to learn" was ranked as the most important characteristic in enabling and defining transdisciplinarity. This learning refers to the development of a common language or knowledge of transdisciplinary approaches that support the synthesis of knowledge. Previous studies have advised ECRs interested in becoming inter- and transdisciplinary researchers to first develop individual expertise and then learn to understand and communicate across different disciplines (Haider *et al.*, 2018; Kelly *et al.*, 2019). The latter study also highlighted the need to "foster interdisciplinary culture" by supporting ECRs to access opportunities on interdisciplinary skills development or formal training programmes. Another school of thought is that individuals should train in "facilitating knowledge integration and developing theories, methods, and tools for [I]TD". Without necessarily anchoring this transdisciplinarity in any one specific discipline (Guimarães *et al.*, 2019: 13). In both scenarios, transdisciplinary training to develop cognitive facilitation and communication skills in the early stages of a research career is viewed as essential for developing the necessary skills to approach the increasingly complex societal challenges we face (Hollaender *et al.*, 2008; Pohl and Hadorn, 2008; Wilson *et al.*, 2021; Nyboer *et al.*, 2022), and this is something that could be further prioritized by research institutions, funding institutions, and the UN Ocean Decade. Future work should also engage in discussions on whether all researchers are prepared or equipped to undertake transdisciplinarity in their work.

While transdisciplinary research needs to include non-academic actors (Figures 4 and 5; Mauser *et al.*, 2013; Manuel-Navarrete *et al.*, 2021) the knowledge generated by some participants, such as Indigenous communities, has largely been ignored in traditionally western(colonial) research agendas (see Smith, 1999; Johannes *et al.*, 2000; Chilisa, 2019). The historical disregard of this valuable knowledge has misinformed management (Johannes *et al.*, 2000), created distrust between the disregarded actors and researchers and in some instances has been used against Indigenous communities further fueling animosity (Keane *et al.*, 2017). Decolonized research methodologies are key to

implement an effective transdisciplinary research program. Importantly, we must consider that: "Colonisation is a structure and not an event, where indigenous and traditional people are forced to work within the constraints of a Western system" (Fischer *et al.*, 2021). Furthermore, what is constituted as "science" in academic institutions also has a history of dominating a particular way of knowing (Chilisa, 2019; Lipscombe *et al.*, 2021). This includes research and educational institutions that have performed research that has been used to marginalize Indigenous people and push colonial agendas (Chilisa, 2019). Tensions therefore exist between the purpose of scientific research and Indigenous people on which research is focused or conducted to benefit.

In order to develop decolonized transdisciplinary research methodologies, ECRs, as the future of transdisciplinary research, need to consider and conceptualize how previous research practices may have marginalized non-academic stakeholders. Building trust and relationships with participants before conducting research will better facilitate a transfer of local knowledge. Furthermore, researchers will need to maintain flexibility in their planning and execution of methodologies as the needs and contributions of partners emerge. As a result, ECRs should embrace methodologies that evolve within the process of discovery, where the direction of the research is driven by existing knowledge instead of assumptions and generalizations (Newbrough, 1995). It is important to understand how local knowledge may have previously been ignored (see Ndlovu-Gatsheni, 2013), be sensitive to the situation and allow methodologies to adapt to a specific narrative (see Nhemachena *et al.*, 2016). Awareness of how knowledge co-production with non-academics is often influenced by "asymmetric power relations and colonial patterns of behaviour" that are rooted in academic culture and practices is also important (Manuel-Navarrete *et al.*, 2021). ECRs can strive to achieve equity in research practices if consideration is given to different ways of knowing, knowledges and knowledge systems (Manuel-Navarrete *et al.*, 2021). This reiterates the need to build capacity and skills to conduct this, and to share tools, good practices, as well as lessons learnt, among researchers to enhance capacities. Supporting capacity-building processes of researchers to conduct more equitable knowledge production could therefore be a key task for the UN Decade of Ocean Science.

Acknowledging that ECRs are in many cases pioneers of transdisciplinarity, supervision for such methodologies may not be readily available. Senior researchers responsible for ECR development and support should therefore be open to the challenges presented by methods developed by ECR projects and their established or favoured techniques for knowledge creation. ECRs have the opportunity to influence the future of academia and advocate a move towards a more pluriversal (instead of a one-size-fits-all universal) view of science and knowledge production that recognizes a multitude of knowledges, knowledge production methods, and knowledge outputs (see Mignolo, 2000). Recognizing that transdisciplinarity is an evolving concept, ECRs working within transformative ocean governance should consider whether their conceptualizations and applications of transdisciplinarity recognizes the possible coloniality of research methods, critically engages with assumptions of universality and challenges asymmetrical power relations between different knowledge holders. Recommendations for how ECRs could address such aspects include:

- actively include and cite other sources/knowledge outputs in research, such as oral stories, fiction, poetry, songs, and art, as well as policy briefs and non-academic reports;
- publish in open access journals (and request publishers to waive or reduce open access fees for researchers and institutions in the "Global South" if these are prohibitive);
- ensure sources and authors cited are contextually relevant to the research and argument;
- include research "participants" as collaborators and co-authors on research design and outputs;
- actively cite and include "Global South" authors and institutions;
- consider translation of research outputs to the home language of participants or relevant communities;
- scrutinize research methodologies utilized in cited research.

Does it matter that we are not in consensus?

ECRs that are hoping to make a career within academia are often under pressure to produce research outputs, and more specifically publish papers in prominent peer-reviewed journals. For transdisciplinary research to challenge top-down, vertical, asymmetric, and universal knowledge production methods, it is necessary that (i) non-academic stakeholders are recognized as experts in their own right, (ii) alternative research outputs are recognized as "science", and (iii) access to peer-reviewed research is improved (through e.g. translations, diversifying science communication methods and open access publication).

Although only some conceptualizations of transdisciplinary research emphasize the importance of involving non-academic stakeholders throughout the knowledge production process, the scientific community needs to strive to make it practically feasible and to contribute to the recognition that "truth" does not necessarily reside within academia. As agreed by the ECRs (see the section "Characteristics of transdisciplinarity"), this will require willingness to learn, respect, collaboration, trust, and time. The increasing emphasis on transdisciplinary research to fulfil the UN Decade of Ocean Science and advance towards the UN SDGs could offer great opportunities for ECRs to conduct critical research for transformative ocean governance. This progress could be strengthened if transdisciplinarity were to be conceptualized and practiced in a more unified manner across the globe.

Conclusions

Following a literature review and a series of surveys and workshops amongst ECRs within the OOH, the group of ECRs reached consensus regarding the importance of involving non-academic collaborators in developing co-designed knowledge production for transformative transdisciplinary research projects. However, this requires skills, time, and resources, making it vital for research institutions, established practitioners, funders, and international programmes such as the UN Ocean Decade to support ECRs in these collaborative research endeavours. The paper has also identified common uncertainties and challenges of practising transdisciplinarity. These challenges include capacity building and training in methods and approaches that support the equitable

participation of non-academic stakeholders, a lack of flexible funding mechanisms, and a clear definition of transdisciplinarity in ocean governance research, which can also be prioritized by the UN Ocean Decade.

The paper further finds that ECRs should ready themselves to take on transdisciplinary research for transformative ocean governance, which includes addressing complex, multi-faceted challenges and focuses on creating impact. This means that the challenges should be identified and conceptualized with non-academic collaborators, which will entail building relationships, engaging and collaborating with stakeholders outside of academia. This is ideally realized through horizontal partnerships, where stakeholders are recognized as collaborators and take part in or benefit from research outputs. Such work typically involves facilitating compromise between interests, navigating diverging epistemologies, and ontologies, and managing expectations of collaborators. ECRs will need to be flexible, adaptive, responsive, and inclusive in their work, as transdisciplinary research and transformative ocean governance will always tend to be dynamic. The challenges experienced in conducting transdisciplinary research for transformative ocean governance highlight the importance of the UN Decade for Ocean Science to support capacity-building processes for emerging researchers in transdisciplinarity and impactful research with non-academic collaborators.

Supplementary data

Supplementary material is available at the *ICESJMS* online version of the manuscript.

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Author contributions statement

Study conception and design was developed by MW, HN, KOC, and MS. Material preparation, workshop facilitation, data collection, and initial analysis was performed by MS, KOC, and HN. Second stage of analysis was conducted by all authors and summarized in the first draft of the manuscript, which was co-written by all co-authors and collated by MS. The manuscript revision was then led by MS, with contributions from all authors. All authors read and approved the final manuscript.

Data availability statement

The data underlying this article will be shared on reasonable request to the corresponding author.

Conflict of interest statement

The authors have no conflicts of interest to declare.

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