ORIGINAL RESEARCH

Equity of our future oceans: practices and outcomes in marine science research

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Abstract The United Nations Sustainable Development Goals (SDGs) aspire to a society where ways to improve inclusivity and diversity of equity are actively explored. Here, we examine how equity is considered in a suite of papers that explored possible sustainable futures for the oceans, and mapped out pathways to achieve these futures. Our analysis revealed that a large range of equity issues were recognised and considered, in outcome-based (i.e. distributive), process-based (i.e. procedural) and concept (i.e. contextual) dimensions. However, often, the equity problem was not explicitly stated. Rather it was implied through the action pathway identified to move towards a more sustainable future, highlighting that reducing inequity is interlinked with improving sustainability. Based on these findings, we reflect on the way equity is conceptualised and considered within this work as well as futures science for the oceans more broadly. A key lesson learnt is that science and knowledge production are immediate areas where we can work to improve equity. We can build capacity to understand and include equity issues. We can develop mechanisms to be more inclusive and diverse. We can

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also critically reflect on our own practices to fundamentally challenge how we work and think in the space of marine science research.

Keywords Equity · Sustainability · Oceans governance · Resource use

Introduction

With changing ocean conditions and accelerating human enterprises, benefits and burdens, fairness and justice, are distributed and governed differently across socio-ecological systems (Jouffray et al. 2020). Over recent decades, the ocean has seen escalating use and extraction of resources. This includes the growth of aquaculture, deep sea mining, shipping, and tourism, and increases in other stressors such as plastics and pollution. With a projected human population of 8.5 billion by 2030, approximately 40% of which live within 100 km of the coast, demands and stressors on oceans are expected to increase. This will compound the already substantial challenges of equitable use and sustainable development.

Recognising the critical role of the ocean in the future of our society, the United Nations proclaimed 2021–2030 a Decade of Ocean Science for Sustainable Development. The decade aims to improve the trajectory of ocean health by bringing diverse stakeholders together behind a common framework to ensure science can fully support improved conditions for sustainable development of the ocean. However, inequity is a systemic characteristic of the current ocean economy. Major changes are required over the coming decades to achieve sustainable development of the ocean in a way that benefits everyone (Österblom et al. 2020).

Equity is a concept rooted in Western law, philosophy and political theory (Hay 1995). Equity is understood differently in the experience of Traditional and Indigenous Peoples in the autonomous and—in most cases—surrendered governance, culture and knowledge that is endemic to those peoples (Fischer et al. 2020). Indeed, little is published in the Western scientific literature of pre-colonial concepts of customary equity between humans and the ocean. Furthermore, equity is understood differently again by a range of marginalised groups experiencing intersecting forms of inequity (Kleiber et al. 2017; Lokuge and Hilhorst 2017; Cohen et al. 2019; Saunders et al. 2020).

Acknowledging this pluralism of understandings, we ask how ocean science can support more equitable practices and outcomes for sustainable development of the ocean. We start by defining equity and highlighting the limits of Western equity theory, before discussing the role of science production in exploring equity under future ocean conditions. We analyse twelve science-informed fore-sighting initiatives in ocean and marine studies. Collectively, this suite of papers outline pathways and associated actions to move towards sustainable futures and achieving the Sustainable Development Goals (SDGs) in the context of climate change (Trebilco et al. 2020), biodiversity conservation (Ward et al. 2020), food security (Farmery et al. 2020), ocean literacy (Kelly et al. 2021), plastics and pollution (Puskic et al. 2020), human health (Nash et al. 2020b), coastal and deep sea blue economy (Bax et al. 2021), climate-driven species redistribution (Melbourne-Thomas et al. 2020), ocean governance (Haas et al. 2021), international relations (Smith et al. 2020) and Indigenous rights and access (Fischer et al. 2020). We ask: how will these ocean futures, and the pathways to achieving these futures, help the SDGs to achieve higher or lower levels of equity?

Background

Defining equity

Equity is defined as 'fairness' and 'justice' in the ways people are treated, according to the Cambridge Free English and Merriam Webster dictionaries. Indeed, the concepts of fairness, justice and equity are considered cornerstones of a healthy society in Western culture (Carrell and Dittrich 1978). They have their antecedents in the moral philosophies and political theories of Aristotle and Plato, and more recently of Rousseau, Locke and Hobbes. But what does it mean to be treated in a fair and just manner? These questions have long been contested because the concepts are so situated in context, power relations, subjectivity, culture, and personal experience. This renders a universal definition of equity impossible.

Amid the race riots and racial inequalities of the mid-twentieth century the concept of 'social equity' was applied by Frederickson (1971) to account for the role of social policy and public administration in the fair, just and equitable development of public policy and distribution of public services. Much social equity scholarship has focused historically on race, gender, and class as domains, but there are a variety of inequity foci including for example: ethnicity, sexual orientation, religion, region, disability status, immigration status, and language of origin (Wooldridge and Goode 2009). The concept of environmental justice as it relates to unequal distribution of the negatives from environmental degradation also gained currency (e.g. Pellow et al. 2001).

More recently, there has been renewed interest in the concept of social equity and the role of international institutions, such as the United Nations, arising in part from the challenges of globalisation and climate change (Guy and McCandless 2012). Both procedural and distributive dimensions of equity are acknowledged in various global governance initiatives and assessments, including the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP); the Intergovernmental Panel on Climate Change (Allen et al. 2018), and the United Nations SDGs.

Confronting the limits of Western equity theory

In considering how equity is pursued and the extent to which it is manifest, tensions in its conceptualisation and application must be attended to. Equity as applied and monitored in global goal-setting programs, such as the SDGs, assumes the universality of the Western legal conceptualisation of what constitutes fairness and justice and how these should be measured. In contrast, the *United Nations Declaration on the Rights of Indigenous Peoples* (2007) acknowledges the legal and moral systems of governance of Traditional and Indigenous peoples in which conceptualisations of equity differ (Donnelly 1984).

Dominant views of equity have a political-legal history. Through the colonial process lands were re-named, re-defined and subjected to a set of values and norms that had been designed as a vehicle of legitimating the incoming colonial rule. In many parts of the world this justification was based on the Euro-centric concept of "Terra Nullius" of empty lands in need of and subject to conquest. In the ocean, the first treatise on international law, Mare Liberum (The Free Sea) outlined a pervasive global sentiment that "the sea, since it is as incapable of being seized as air, cannot be attached to the possession of any particular nation" (Grotius 1609). In the twenty-first century whilst critical academic, historical and socio-political processes have exposed the root causes and structural violence embedded in these legacies of conquest, the global structure of how power, equity and politics flows still contains elements of the "old power". Therefore, progress on "equity" in our ocean must be viewed also in the context of structure-agency: whose equity and fairness, when and in what context?

These tensions include the call for greater attention to the role of power in deciding what is fair and just, informed by the works of theorists such as Marx, Foucault, Habermas, and in recognising power, as well as capital, as resources or benefits in themselves which are inequitably distributed (Cook and Emerson 1978). Access to these can have a determining influence on the ability of marginalised groups (for example, ethnic minority groups) to participate equitably in processes seeking procedural justice administered by institutions designed to give them 'equality of opportunity' (Mentovich 2012; Gustavsson et al. 2014).

Further, they include the call to expand the scope of for whom or what equity is sought to be inclusive of non-human entities and concerns (Fitzmaurice 2008; Preston 2018; Spijkers 2018). This contrasts with the treatment of the earth as a resource to which humans and future generations of humans have rights, as expressed in various global governance instruments. In a personal story told to the authorship team, which illustrates thinking about the health of the ocean as intertwined with our own survival, Taiwanese Indigenous leader Sutej Hugu defined the teaching of *mavaheng so panid* (the noble black-wing flying fish, *Hirundichthys rondeletii*) to the ancestors of his Tao people:

> The teaching includes two major parts: firstly, the inter-species compact for the survival and sustenance of peoples and fish and the eco-calendar, ahehep no tao, that defines the arrangement of works and ceremonies all around the year (see Mustonen et al., Upcoming). This points to the ways that Indigenous peoples saw the ocean and her species as relatives and

developed temporal and spatial means of co-existence over time—many of which were seen as evil, bad or hindering modernity and progress by outsiders during the hey-day of the colonial process (and therefore a subject of termination often).

The expansion of the community of justice or moral community to encompass notions such as interspecies equity (Bosselmann, 2016) has arisen in acknowledgment of their inherent value, as well as of the role of natural systems in human wellbeing and flourishing.

Role of science production in exploring equity under future ocean conditions

Science-informed fore-sighting initiatives in ocean and marine studies are arenas in which visions of greater equity as central elements of a desirable ocean future are increasingly being included (see Merrie et al. 2018). Ways to improve inclusivity and diversity of equity as concept, process and outcome are being actively explored. For example, Raudsepp-Hearne, Peterson et al. (2020)'s scenario development approach is specifically designed to encompass the less tangible features of political economy, heterogeneity in values, and cultural diversity to identify system characteristics that would offer more sustainable and just futures. One reason for this is the increasing trend towards interdisciplinary ocean and marine science and integrated solution-oriented research (Visbeck 2018). This trend allows inclusion of disciplines that have long explored issues of equity (e.g. social sciences), which make equity more likely to be explicitly considered and approaches that allow equity issues that surface more likely to be employed (e.g. co-production techniques).

The SDGs "represent today's most relevant globally negotiated normative agenda for sustainability" and "a turning point in defining what sustainability means on a global scale" (Schneider et al. 2019). The development of the SDGs was aimed at improving inclusivity and diversity in response to critiques of the previous Millennium Development Goals. Yet the SDGs and the pathways to realising them still largely avoids requiring a fundamental re-alignment of the social structures and institutions in which inequity is often embedded (Battersby 2017). Furthermore, while the SDGs recognise that equity is an essential pathway

to sustainability, the system transformation that this would require is not addressed; how equity is to be achieved is far less clear (Sexsmith and McMichael 2015). The SDGs are a high-level aspirational vision of a desirable society but lack guidance in how to address conflicts in values and trade-offs in decision making across targets and outcomes to achieve that vision (Schneider et al. 2019).

Methods

Analytical framework

To identify the ways in which the concept of equity was considered in science-informed fore-sighting initiatives in ocean and marine studies, we firstly developed an analysis framework based on our review of the literature (Fig. 1). This framework was comprised of three key dimensions of equity. The first dimension was the outcome-based/distributive dimension, referring to the consequences of a policy, action or developmental trend, e.g. equity in the distribution of benefits and burdens (inclusive of costs as well as responsibilities) between genders, races and ethnic groups, species, classes and nation states. The second dimension was the process-oriented/procedural dimension, referring to impartiality and fairness in the process of delivering and administering justice. The third was the concept/contextual dimension, referring to informing cultural, political, economic and social world views, knowledge systems, actors and attributes of the situation, peoples and natural systems, and the interrelatedness of ecological conditions to these.

For each dimension, a sub-set of conditions were identified. The literature drawn on to compile these conditions comprised applied studies which addressed matters of equity in relation to oceans and communities of users and interests (e.g., Ntona and Morgera 2018; Frangoudes et al. 2019; Campbell and Hanich 2015). For full details of this framework, see Supplementary Table 1.

Data sample

For our sample of science-informed future fore-sighting initiatives in ocean and marine studies we used the twelve papers included in this *Reviews in Fish*
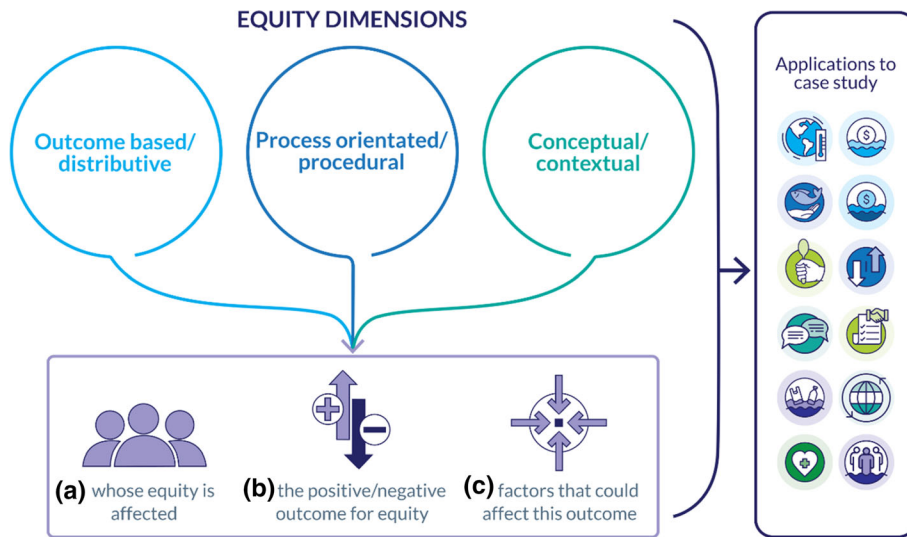
Fig. 1 Analytical framework; for further case study details see Table 1

Biology and Fisheries Special Issue (Table 1) which are outputs from the large Future Seas initiative (https://futureseas2030.org/). We considered this to be a relevant sample to analyse as these papers covered a wide range of marine issues and dimensions, and the authorship teams covered a diversity of disciplines and knowledge systems. The co-authors were of all career stages, from 28 different organisations, and comprising 20 different nationalities with, collectively, substantial research experience across all seven continents (Nash et al. 2020a). In addition to Indigenous and Traditional knowledge holders, the disciplinary expertise of the Future Seas project team included ecology, climate science, oceanography, marine engineering, mathematics, philosophy, social sciences, economics, finance, political sciences, law, behavioural psychology, medicine, and public health, with many disciplines being represented in most papers (Nash et al. 2020a). At the stage of review, all papers were pre-peer review drafts.

Data analysis

The sample was reviewed using our equity analysis analytical framework (see Supplementary Table 1). All authors on this paper were co-authors on at least one of the case study papers analysed. Analysis of the case study papers was distributed across co-authors based on familiarity with the topic of each paper. For each dimension of equity, we assessed whether and which sections of each paper explicitly addressed that dimension, and in relation to what issue. Where equity was specifically considered in at least one dimension, we then asked a) whose equity was affected, b) the positive/negative outcome for equity, and c) what was proposed in the pathway to a sustainable future that could affect this. Gaps in the analysis were filled in as necessary and the framework was, as far as possible, applied consistently. Finally, data were input into an Excel spreadsheet so that patterns and gaps could more easily be identified in the equity dimensions and specific issues addressed or not addressed across the sample.

Results

The results of the analysis are presented in two ways: (i) in a table format which shows whether each paper explicitly addressed that dimension; and (ii) in-text where we provide examples of who was affected and how, and what was proposed to address this.

Analysis of the papers revealed that a large range of equity issues were explicitly recognised and considered across the papers, across all three dimensions (Table 2). Outcome-based/distributive equity issues were the most highly recognised, as were the decision-making-related components of procedural equity.

Table 1 Overview of data sample of papers analysed to assess outcome-based/distributive, process-oriented/procedural and concept/contextual dimensions of equity in the pathways required to move towards achieving sustainable futures for the ocean by 2030. Short titles (as referred to in-text) are in **bold**

Icon & reference	Title	Problem	Drivers	Sample actions
Trebilco et al (2020)	**Warming world, changing ocean**: mitigation and adaptation to support resilient marine systems	How to achieve a healthy, resilient, safe, sustainably harvested, and biodiverse ocean	Extreme events; human intervention to reduce climate change; appetite for climate action	Creation & enhancement of economic incentives for climate mitigation & action; deploying marine-based renewable energy; deploying marine-based negative emissions technologies
Ward et al (2020)	**Safeguarding marine life**: conservation of biodiversity and ecosystems	How to safeguard marine ecosystem biodiversity, function, and adaptive capacity whilst continuing to provide vital resources for the global population	Financial mechanisms, sectoral stewardship, management and governance, societal impetus	Upscale predictive capacity, expand & fund monitoring programs, increase & enhance Indigenous management & partnerships, streamline knowledge exchange
Farmery et al (2020)	**Food for all**: designing sustainable and secure future seafood systems	How can the ocean contribute to sustainably feeding the world's population	Ecosystem change; ocean governance; influence of corporations; output & efficiency of seafood systems; consumer demand; focus on nutrition	Diversification of production & consumption; co-management of marine resources; supply chain transparency; sustainable feed inputs; awareness-raising on nutritional value of seafood
Kelly et al (2021)	**Connecting to the oceans**: Supporting ocean literacy and public engagement	How to improve societal connections to the ocean	Education; cultural connections; technological developments; knowledge exchange & science-policy interconnections	Ocean literacy targeted across society; develop programs that are inclusive of local contexts and culture; maximise utility of technology; inclusive approaches
Willis et al. (2020)	**Cleaner seas**: reducing marine pollution	How to reduce marine pollution	Societal behaviours, equity and access to technologies; governance and policy	Outreach & education campaigns; use of gross pollutant traps; recycling of fishing gear
Nash et al (2020a, b)	**Oceans and Society**: Feedbacks between ocean and human health	How to promote desirable & minimise undesirable interactions between ocean and human health	Worldview, decision-making context, approach to behaviour change; power & agency; human development & industry; food system; lifestyle & connectedness to ocean	Science & health communication upscaled and improved; knowledge exchange; changed incentives and rules and regulations to change behaviour;
Bax et al (2021)	**Ocean resource use**: building the coastal blue economy	How to manage sustainable development in future exploitation of both over-utilised and emergent coastal resources	Conflict resolution	Recognising the problem & committing to action; co-management by multiple reliant groups; implement networks to maintain and enhance biodiversity

Table 1 continued

Icon & reference	Title	Problem	Drivers	Sample actions
Novaglio et al. (2020)	**Deep aspirations**: towards a sustainable offshore Blue Economy	How to develop a sustainable offshore Blue Economy	Governance, research & innovation; values of the ocean; partnership	A shift of societal values; sustainable & equitable financing; information sharing; improved legal & institutional mechanisms
Melbourne-Thomas et al (2020)	**Poleward bound**: adapting to climate-driven species redistribution	How to manage & adapt to species redistributions and minimise negative impacts on ecosystems and human communities	Monitoring & detection; managing at multiple scales; cooperation between jurisdictions; human adaptation	Event-driven sampling; implementation of dynamic ocean management; improved communication & coordination between nations; knowledge co-production
Haas et al (2021)	The future of **ocean governance**	How to move towards more sustainable ocean governance aligning with SDGs	Formal rules & institutions; evidence & knowledge-based decision-making; legitimacy; stakeholder engagement & participation; empowering communities	Place-based management & planning; innovative marine business models; fair decision-making process; benefit sharing arrangements; capacity building; long-term co-operation
Smith et al	**Sharing our oceans fairly**: improving international relations around ocean issues	How to ensure international relations around oceans issues are fair	Governance; value of ocean; politics; transparency; engagement; goals	High-level political commitments; changes to governance structure; participatory justice; clear transparent communication
Fischer et al (2020)	**Empowering her guardians** to nurture our oceans future	How to envisage a fair ocean future for Indigenous and Traditional Peoples around the world	Colonisation and globalisation	Indigenous and Traditional Peoples to be handed power to make decisions over coastal & ocean spaces; scientists & practitioners to challenge processes, structures & strategies that do not include Indigenous & Traditional Peoples voice

Regarding the context of each paper, there was a substantial recognition of issues relating to the types of knowledge used to address the challenges described (e.g. Western science or Indigenous knowledge), as well as issues relating to agency. Often, the equity problem was not explicitly stated within the papers, but rather recognised through the action pathway identified to move towards a more sustainable 2030. In other words, reducing inequity was interlinked with improving sustainability. For this reason, most of the examples provided in this synthesis will relate to the action pathways identified in the papers.

Outcome-based/distributive dimension analysis

Of the outcome-based/distributive dimension of equity, the conditions most addressed by the challenges were: access to ecosystem goods and services; access to basic human rights; access to culturally important areas, species and communities; and financial capital created from marine resource-based industries (Table 2).

Access to basic human rights most commonly focused on issues around food security for all. For example, 'Food for all' proposed a pathway action of regulatory and market-driven improvements in

Table 2 Results of the analysis of the direct recognition of the three dimensions of equity based on explicit references from each of the 12 papers analysed in this study

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
Benefits/burdens												
Access to basic human rights			●			●	●		●	●		●
Access to available ecosystem goods & services	●	●	●			●	●		●	●		●
Access to culturally important areas, species & communities	●	●	●	●			●		●	●		●
Access to public services		●	●	●	●							●
Financial capital created from marine resource-based industries		●	●			●	●	●	●	●		●
Access to share of economic benefits or rents created	●		●			●	●		●		●	●
Impacts/benefits of environmental degradation	●		●	●								●
Impacts of natural disasters			●									●
Impacts/benefits of environmental change	●		●			●			●	●		●
Other				●			●					
Process/procedure												
Access to decision-making processes		●	●				●		●	●		●
Input into decision-making	●	●	●		●	●			●	●	●	●
Quality of decision-making processes	●	●	●				●		●	●		●
Affordance of dignity and respect	●		●						●			●
Neutrality/benevolent intentions of decision-makers											●	
Other									●			●
Conceptual/contextual												
System of law in place to determine what is fair & just	●		●							●	●	●
Degree of agency held by those affected by change	●		●	●		●	●			●	●	●
Types of knowledge systems used to understand change		●	●	●	●	●	●		●	●	●	
Who/what is included in scope of just & fair treatment			●			●	●		●			●
Level of economic capacity required to participate in change		●	●	●	●	●					●	
Other				●								●

domestic and low-value seafood chains to enable equitable access to food, whereas 'Ocean resource use' proposed integrated and participatory management to increase food security. The focus of access to ecosystem goods and services included fisher access to fish stocks and local community access to coastal and marine areas. For example, 'Oceans and society' recommended enforcing public access to coastal and marine areas, whereas 'Poleward bound' proposed a pathway action of creating indigenous and community conserved areas.

Indigenous peoples were the main group perceived to be affected regarding access to culturally important areas, species and communities. To address this, many of the papers focused on the need for recognition of Indigenous Peoples' rights, and inclusion of Indigenous Peoples' knowledge and cultural values. As examples, 'Warming world, changing ocean' proposed increased inclusion of Indigenous perspectives, and 'Safeguarding marine life' proposed the recognition of Indigenous peoples and traditional owners as the guardians and managers of marine areas. In regard to access to public services, various topics were addressed including the need for engagement and literacy programs to improve mental health (Connecting to the ocean) and the need to make science more discoverable and communicated (Safeguarding marine life).

The focus for financial capital created from marine resource-based industries was primarily commercial and recreational fishing—both in terms of changes to subsidies and rights for small-scale fishers. Furthermore, 'Oceans and society' proposed that incentives to provide micro-loans for green technology may assist disadvantaged groups whilst 'Deep aspirations' suggested that private–public benefit sharing mechanisms could help to address benefit hoarding by corporations and wealthy nations. 'Oceans and resource use' highlighted how benefit sharing requires engaged knowledge holders and conflict resolution tools to

assist during a transition to sustainable livelihoods. Importantly, 'Empowering her guardians' made clear that recognising the maritime rights of Indigenous and Traditional Peoples, eradicating colonialism, and stopping prejudice against Indigenous and Traditional knowledge systems would start to address equity across the distributive dimension.

Process-oriented/procedural dimension analysis

The analysis of the process/procedure-based dimension of equity revealed that the conditions most addressed were input to decision-making; access to decision-making processes; and the quality of decision-making processes.

A variety of groups were recognised to have restricted access and input to decision-making processes including minority groups, small scale fishers, women, people from diverse ethnicities, and nation states themselves. Collaboration and inclusivity in decision-making frameworks were proposed as a means by which to increase participation by such groups. For example, 'Oceans and society' proposed participatory governance to decentralise power, moving it away from private corporations; 'Deep aspirations' proposed that international collaborative governance interventions may enable input from Indigenous and traditional peoples; and 'Ocean governance' proposed the creation of reflexive, balanced, transparent and inclusive decision-making frameworks to address disenfranchised groups. 'Sharing our oceans fairly' noted that in international treaty negotiations, there should be an extensive consultation process to ensure the inclusion of the global communities' interests.

Regarding quality of decision-making processes, the papers often recognised that everyone in society was likely to be affected by the changed discussed. Transparency, consultation, and knowledge sharing were viewed as the key requirements to improve quality of decision-making and equity of process. 'Warming world, changing oceans' suggested that ethical principles should be used to determine when incentives or regulation is used, and for whom. 'Ocean governance' suggested a pathway action of transparent consultation processes led by accountable authorities.

Concept/contextual dimension analysis

The types of knowledge systems used to understand change was the most commonly recognised context factor across all papers. Almost every paper recognised equity issues regarding the types of knowledge systems that are used to address sustainability with level of economic capital, capacity required and degree of agency held also being recognised by more than half of the papers.

The dominance of Western scientific knowledge was identified, as was the need to incorporate Indigenous and experiential knowledges. Collaboration and co-production of knowledge were proposed as the key routes towards addressing this equity issue. For example, 'Food for all' proposed that co-production of knowledge and technologies was required, whereas 'Ocean resource use' proposed the need for determination of strong sovereignty to underpin economic access, sustainable livelihoods and conservation.

Many papers also recognised that developing countries, and communities with less resources may find it more difficult to achieve sustainability due to financial restrictions, particularly regarding technical solutions. For example, 'Connecting to the oceans' noted that a 'digital divide' was driven by limitations of technical literacy for lower income and less well-educated populations and 'Ocean resource use' noted that landless peoples may be unable to engage in alternative livelihoods which would remove pressure from the marine environment. Although several of the papers recognised that capacity and capability needed to be developed, in most they were limited to identifying activities and groups for whom this capacity and capability development needed to occur, rather than options and pathways through which these could be further developed. For example, in 'Food for all' the need to ensure emerging mariculture and other seafood production and storage technologies were available and accessible to small-scale coastal and fishing communities experiencing food insecurity and potentially transition away from fishing was noted but enablers were specific to scenarios, such as community partnerships with non-government development organisations.

Lastly, the papers identified several groups whose agency was likely to be affected by the move towards a more sustainable future, including Indigenous groups and 'gate-keeper elites'. 'Connecting to the oceans'

specifically noted that an environmental education focus in schools places a burden on the next generation. Pathways to address such issues largely focused on enabling social learning, and increased empowerment. 'Sharing our oceans fairly' proposed commitments to capacity building and technology transfer, particularly to small island developing states (SIDS). 'Empowering her guardians' advanced Indigenous and Traditional peoples' self-governance as a means by which to address this issue.

Discussion

The ocean is acknowledged as a domain where considerable inequity exists in terms of benefits that are generally accumulated by a few and yet costs often borne by the most vulnerable (Österblom et al. 2020). Over the coming decades as trends associated with climate change (Pörtner et al. 2019), and the great 'blue acceleration' both continue to grow, we run the risk of existing equity issues being magnified and growing more urgent, rather than moving towards resolution. Globally, regionally, and locally, our plans for the ocean need to consider equity in a much broader way than has been done to date. As highlighted in the recent Blue Paper by the High Level Panel for A Sustainable Ocean Economy "Shifting a historical trajectory of persistent and increasing inequities will require strong leadership, inclusive governance and long-term planning that starts with a commitment to equity as integral to a sustainable ocean economy and relationships within and across nations" (Österblom et al. 2020). Issues of ocean equity are not challenges that the marine research sector can solve alone. However, as a research community we can start to make the changes needed to achieve more sustainable ocean futures with improved equity outcomes.

The process of engaging with these questions of equity provoked significant personal and collective reflection amongst the co-authorship team. This concerned the way equity is conceptualised and considered within the sample of futures science for the ocean, and the way it was practiced within our own research co-production for this manuscript. We distil these reflections below and highlight some of the key lessons we aim to take forward in future work.

For the involved Indigenous and Traditional Peoples and their communities, the central understandings flow from Sutej Hugu, described to the authorship team as summarised below.

> When Indigenous governance of seas and oceans has (had) the time and space to operate within it is own scales and manner, it is often an interspecies compact building on strict laws of the sea as defined in the Indigenous governance of how humans belong with the sea. The sea and the ocean is a living, providing being which should not be under any circumstances angered or abused.
>
> Equity is building on an understanding of deep interconnections with species and humans as manifest for example in Taiwan between the Tao and noble black-wing flying fish, *Hirundichthys rondeletiid*, or any other deep relation across the world on these profound connections. They form the basis of traditional concepts of equity that have since, for a number of reasons, including colonial process, self-destruction of these values and systems and imposed power structures, been lost or survived to varying degrees. However, it is important to realize that such systems have been in place and delivered endemic notions of equity as a part of the Indigenous governance of the seas historically, and in part today.

In a marine context, although we recognise that it is not limited to fisheries and harvest, it is evident that small scale fleets and harvesters (Isaacs et al., n.d) are often the keepers of remaining equity management and co-existence mechanisms but are also mostly affected by the large fleets through e.g., exclusion of quota allocations and destruction of habitats and stocks. Whilst care has to be taken to investigate each small-scale fishery case on their own, we can learn from each case and global solidarity and unity for diverse indigenous and smaller scale fisheries can be found across continents (Isaacs et al., n.d), traditional systems (Mustonen and Huusari 2020) and globally (Mustonen et al., Upcoming).

Equity is more than achieving material outcomes or implementing processes: Addressing equity is coupled with achieving the SDGs but to be enduring, equity must focus on more than just outcomes or process. It is also about context, including the values, power, accountability and capacity of decisions and actions,

and awareness of and reflection upon these things (McKeon 2017). This was almost unanimously recognised by the papers included in this analysis, particularly about knowledge systems, the capacity required, and the degree of agency held. Equity may also be countervailing. This is illustrated in 'Food for all' in which greater equity is achieved materially by providing greater access to fish stocks for small-scale subsistence fishers but which may be at the cost of localised depletion of fish stocks. Acknowledging this complexity and supporting decision-making for situations when equity and sustainability cannot both be achieved is lacking in the SDGs (Sexsmith and McMichael 2015). While universally-declared normative frameworks have come a long way in accepting the need for equity, the mechanisms required to achieve equity, including fundamental challenges to current systems, institutions, power arrangements and values with potentially uncomfortable trade-offs and conflicts are less tangible. Furthermore, equity can never be finally achieved, it is always in a dynamic state (Boyle 1993). To be equitable is to shift and change to share the balance of power and consequences.

Equity is inherently relational and morally grounded: Equity has critical process dimensions and the pursuit of it needs to reflect the foundational, dynamic, and relational cultural and political context in which what is equitable is defined. Several papers recognised the need for inclusion of multiple knowledge systems, alongside Western science knowledge, to understand the changing ocean and the changing relationships communities have with the ocean. To achieve the ocean we want, we then need progress on all sectors and issues to arrive in a place of restitutive rights and justice, and equity. But even then, equity will not only be about rights, or benefits, rather, also co-dependency and "moral" responsibility to maintain good relations with all components of the system in which we live. In New Zealand, for example relations between people and rivers (and guardianship under Māori culture and tradition) have been established by granting rivers legal standing as personhood (Hsiao 2012, Argyrou and Hummels 2019). In Taiwan, a compact has been established and maintained between Tao people and noble black-wing flying fish, *Hirundichthys rondeletiid*. Equity is therefore not only about rights and undoing of past wrongs, it is also about our responsibilities from daily (Isaacs et al., n.d)

to planetary scales (Mustonen et al., Upcoming) in trying to undo the massive destruction of the past centuries.

Imbedded inequity cannot be overcome by more of the same: Equity as codified in the SDGs is problematic because it does not address how we achieve the social and system change required. Rather, it presumes that those systems that created and embedded inequity will somehow be able to reverse it (Winkler and Williams 2017, Fukuda-Parr 2019). This lack of reckoning with the imbedded nature of some inequities is illustrated in many of the papers examined in this analysis. Inequities are acknowledged as needing to be overcome without including pathways or actions to enable the restitution, rights, capacity building and capital some groups may require. This is further illustrated by the contributive role of, and indeed reinforcement of, existing social inequalities by the COVID19 pandemic and the effects of the responding state-based health measures and associated economic crisis (Ahmed et al. 2020). Grazia Feyerabend, long-time director of the Indigenous and Community Conserved Area Consortium (ICCA) has identified how modern solutions justify countries continuing to do little or nothing on issues such as pollution. Proper 'governance and management units'—which she sees as the crux of the matter—should flow from principles such as subsidiarity, historical continuity, appropriate capacities, and fairness, as well as ecological integrity and meaning (Mustonen et al., Upcoming). Feyerabend (cited in Mustonen et al., Upcoming) has often been doubtful that these puzzles can be solved with the "chainsaw of national legislation and rules applicable equally, top down, to very different conditions and realities". Modern governance has presumed authority, diffused and unclear responsibility and little to no accountability for a great part of the ocean.

Future ocean science must change to support pathways to more equitable futures: There is a strong commitment in the marine-science community to engage with the concept of equity, but there is still much work to be done. As is clear from the analysis, in a couple of instances equity is barely addressed, in some cases engagement with the concept is still superficial or limited to technocratic solutions, but in others there is a clear commitment to on-going learning and change. The process revealed to us that the values deeply embedded in science and knowledge production are not necessarily equitable or enabling of

equity inquiry, as acknowledged more broadly (Ford et al. 2016). We observed the challenges to inclusivity of multiple voices in co-design and production of these science papers arising from a range of institutional characteristics. These included the 'expert' peer review process; the requirement for referencing published ideas from predominantly Western and scientific literature; the specific disciplinary framing of future challenges and drivers; the "echo chamber" effect of co-authors holding (mostly) like-minded views; and the academic focus on ideas with limited participation from those involved in implementation (e.g. policy, government, public). We recognise that these are fundamental and structural issues that could not have been avoided here but are challenges for the future production of science. Moreover, there is a significant gap in training and education and financial support in science to prepare scientists to welcome and value different approaches and develop capability for thinking about equity at all levels and stages of research. Co-design and co-production seem to present promising ways forward to explore issues in more depth and breadth. But perhaps there is a fundamental change in how we move forward, not as experts seeking answers separate from ourselves but as reflective practitioners inviting and working with others to build deeply personal ways forward, together.

Our own practice of marine science and research is not fully inclusive: As an authorship team we collectively have only our own subjective experience and the work presented in published peer-reviewed papers to draw from. It was our explicit intention not to co-opt others voices in a way that reduced their power or changed their intent, which is difficult without deep understanding. We can only ever present a partial and limited view and aim to open a dialogue to include others in an on-going process of learning and reflecting (Winkler and Williams 2017). Inclusion of different voices in different ways is not intended to make those voices 'other' or separate, but the publication process which leads to scientific research papers is restrictive and needs to become more inclusive, especially to those at earlier career stages and diverse backgrounds (Bennett 2018). While the authorship group for this paper does encompass a more diverse group than often encountered, we recognise that more diversity is better, and we recognise the vast number of voices not included in the research undertaken.

More broadly, despite attempts to be diverse and to actively include other voices, marine science production is still the domain of a narrow set of hegemonic interests (white/Western/middle-aged/middle-class/male/positivist scientific) (Bennett 2018). There remains significant work for science and knowledge production to be sufficiently co-produced, inclusive and diverse (Nielsen et al. 2018; Walter and Suina 2019), and we support the multiple efforts across marine science to address these issues. These include: specific science organisation and Indigenous and Traditional Peoples partnerships, such as the Kimberley Indigenous Saltwater Science Project in Western Australia (Western Australian Marine Science Institution 2014); structural corrections in science organisations to address barriers to women's participation in marine science (Sardelis et al. 2017); and formal embedding of local ecological knowledge of small-scale fishers in marine assessments in developing contexts (Berkström et al. 2019). These efforts examine equity as it manifests in futures ocean science. They show that while who gets what (e.g. distributive equity as per the SDGs) is a traditional way of looking at justice, process and procedural equity are equally important. It is also clear that each justice question will be framed differently depending on environmental, economic, and social contexts. Therefore, the basis for decision making must be underpinned by a clearly expressed conceptual framework that is acceptable to all parties and there must be openness to consider transformational change.

Conclusion

Our analysis shows that changes are needed in the way we pursue more sustainable ocean futures if we are to improve equitable outcomes. For example, rights-based approaches to sharing access and resources will need to be broadened to consider more fully who or what warrants rights and how they will be achieved. These changes will include institutional modification but will also need a progressive approach in developing decision-making processes and procedures to enable more equitable outcomes. For example, active measures may be required to ensure disenfranchised minority communities have a voice in these processes. These changes will need to accommodate multiple

moral and ethical world views for relating to our ocean and the communities of concern.

In the context of the Future Seas project, we recognise that science and knowledge production are immediate areas where we have agency and can work to improve equity. This includes improvements in terms of building capacity to understand and include equity issues and develop mechanisms to be more inclusive and diverse. It necessitates a challenge to some fundamental values, at every level (e.g. formal education, research training, project design, metrics of success, resourcing, power hierarchies). Only by challenging ourselves (and others) in ways that feel uncomfortable can we start to create this positive change. As members of the marine research community we commit to taking onboard this responsibility within our own lives and our research collaborations. More broadly this effort needs to be taken on by the majority of researchers engaged in science and knowledge production, to contribute to improving processes in terms of engaging with and scrutinising concepts of, and relating to, equity. If such scrutiny becomes common practice, then processes and outcomes of equity will better reflect responsibility and inclusion of diversity in futures ocean science and in our shared future sea for generations to come.

Availability of data and material Data can be made available on request.

Code availability Not applicable.

Declarations

Conflicts of interest The authors have no conflicts of interest to declare that are relevant to the content of this article.

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