Knowledge Integration in Ocean Governance

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Edited by Dorothea Wehrmann and Annegret Kuhn

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Abstract

The integration of diverse knowledges is considered essential in ocean governance to understand and address the complex and transboundary changes affecting oceans and societies. In this line, also the UN Decade of Ocean Science for Development (2021–2030) calls for "the science we need for the ocean we want" (UNESCO, n.d.) and the 5th International Polar Year (2032–2033) evolves around "the urgent need for coordinated international research to tackle the biggest challenges of polar research, for both the Polar Regions themselves and for the world as a whole" (International Polar Year, n.d.). This thematic issue derives from the notion that the coordination and integration of diverse knowledges to develop advanced understandings is a political process shaped by, amongst other things, societal inequalities and different forms of governance. To assess the implication of this notion for the governance of the oceans—the "common heritage of humankind" (United Nations Law of the Sea)—this thematic issue explores knowledge integration processes in ocean governance. It sheds light on different governance formats, the role of participatory and co-creative approaches to knowledge integration, their potentials, limitations, and related micropolitics.

Keywords

5th International Polar Year; co-creation; knowledge integration; ocean and coastal governance; participation; United Nations Decade of Ocean Science for Development

1. Introduction

As the narratives driving the UN Decade of Ocean Science and the upcoming International Polar Year exemplify there is broad scientific and political consensus that the integration of diverse knowledges in ocean governance is crucial for preserving and restoring sustainable marine ecosystems (see Grip, 2017;

Poto et al., 2021; van Tatenhove, 2011). In this way, ideally knowledge integration shall advance a sophisticated understanding of the challenges and opportunities associated with human (mis-)use and management of the oceans (a), help to map scenarios and identify entry points for political action (b), and to strengthen global justice and avoid policy decisions that perpetuate inequality and domination by some at the expense of others (c). However, knowledge about the actual experiences, formats, and processes of knowledge integration in ocean governance is limited. To concretize demands for policies facilitating knowledge integration, the 13 contributions in this thematic issue introduce new evidence from knowledge integration processes across regions and scales.

2. Knowledge Integration Processes in Ocean Governance

Following Dale and Armitage (2011), we understand knowledge integration processes as part of knowledge co-production processes, which include knowledge integration between different scientific disciplines (interdisciplinarity) but also the integration of scientific knowledge and other knowledge systems (transdisciplinarity). Another dimension of knowledge integration relates to the transfer of knowledges in political processes, which may also imply the effective political participation of knowledge holders as a necessary element of knowledge integration (see Neddersen et al., 2025). Despite the potential ascribed to knowledge integration, its actual impact depends crucially on the socio-political and socio-economic context (see Champion & Strand, 2025). Following Mondré and Kuhn (2022, p. 6), we understand ocean governance as "all rules, policies, laws and institutions designed by either governmental and/or non-governmental actors—on all levels of decision-making—that regulate any human activities with regard to the ocean." Accordingly, the contributions to this thematic issue highlight different governance formats and institutions as well as participatory and co-creative approaches.

2.1. Governance Formats and Institutions

Various contributions investigate how knowledges are considered in ocean governance and emphasize the need to broaden knowledge perspectives. In this way, Rafliana (2025) points out that narratives around tsunamis become more reductionist, with interpretations that are used for tsunami risk reduction measures being prone to contestation. To understand complex human and non-human entanglements, Rafliana introduces epistemic oscillation as a conceptual lens and argues for "alternative ways to unfold the multiplicities of social and geological realities and epistemic mobilities" (Rafliana, 2025, p. 2). Also, Schüpf et al. (2025, p. 1) understand "coastal adaptation as a geophysical and socially intertwined process." By focusing specifically on ocean sand, they demand that future adaptation strategies engage "with the materialities of ocean sand and the social implications of sediment loss for artisanal fishers" (Schüpf et al., 2025, p. 1) to reduce maladaptation. The authors thereby build on the literature on "geosocialities" and understand ocean sand as a non-human actor, whose fluid materiality "provides a lens through which to analyse the hidden complexities of different coastal actors in managing coastal risk" (Schüpf et al., 2025, p. 18). Chávez-Páez and Hornidge (2025) call for governments' approaches to ocean governance to be more holistic. In the context of fisheries management in Ecuador, they show how illegal activities and organised crime shape the ecological and socio-economic dynamics of a region and affect fisheries in nearby communities. This interconnectedness, however, only comes into light if community struggles are understood "as part of a broader tapestry of relational dynamics" (Chávez-Páez & Hornidge, 2025, p. 18) and not viewed in isolation.

Other contributions focus on more general measures for integrating alternative knowledges in ocean governance. For example, Neddersen et al. (2025) point out weak legal provisions which often provide no guidance on how knowledge should be integrated into planning. The authors emphasize that knowledge integration "requires more than just participation," especially in cases with unequal power distribution when dominant actors are able to influence decisions in their favour, as in the case of marine protected area management plans in the German Baltic Sea. The authors suggest advancing legal frameworks and considering "broader and more inclusive participation tools, earlier stakeholder engagement, and [putting] stronger emphasis on social and economic considerations" (Neddersen et al., 2025, p. 16). In a similar vein, Duggan et al. (2025) emphasized meaningful stakeholder engagement and trust. They present a heuristic ("seven rules of thumb") to enable researchers and practitioners to incorporate "sense of place" into ocean governance as a relational tool that they believe can advance knowledge integration, without neglecting broader systemic issues. Gricius (2025), however, reminds us, that whether or not institutional arrangements and mechanisms encourage or hinder the integration of knowledges and perspectives in ocean governance also depends on their mandates. In this way, the Arctic Council, for example, does not consider military security. The distinction between types of security has implications for cooperation under the auspices of the Arctic Council. While Gricius (2025) traces the discourse from the Cold War to the present and finds that Arctic security knowledge is following global security trends such as increasing geo-political competition, impacting the topical issues addressed in ocean governance institutions, Ittner and Hornidge's (2025) contribution brings into focus how administrative fragmentation and knowledge politics by a diverse set of actors affect biodiversity protection. By focusing on the mapping of marine protected areas in the transboundary Borkum Reef Ground, their analysis raises awareness of "undone science" by showing how transboundary research and knowledge production are shaped by administrative requirements and funding priorities. Also, Le Meur and Muni Toke (2025) relate to administrative struggles and the role that historical pathways may play in knowledge politics by analysing how the relationship between France's three non-sovereign Pacific territories and the French state shapes their intra-regional position towards deep-sea mining.

2.2. Participatory and Co-Creative Approaches

The discussion of the role, potentials, limitations, and micropolitics related to participatory and co-creative research approaches in ocean governance is central to various contributions. By focusing explicitly on the UN Second World Ocean Assessment Report (2021), Toupin et al. (2025) investigate how international reports integrate diverse knowledges in assessments guiding ocean governance. They show how the report relies mostly on research published in high-impact journals, and less on specialized sources or a broader dataset of ocean research. In line with the targets of the UN Decade for Ocean Science they see "room for improvement" and introduce a methodological framework for improving knowledge integration in reports informing ocean governance. Also, Schoderer et al. (2025) illuminate systemic vulnerabilities in knowledge integration processes that inform the IPCC report. They emphasize that the large coordination effort, which includes data collection, data provision, and data management, is mostly being taken care of "by entities at the bottom of the value chain" (Schoderer et al., 2025, p. 16) and is vulnerable to fluctuations in funding and staff shortages, weakening coordination platforms and programs.

By relating explicitly to Indigenous and local knowledge systems, Champion and Strand (2025) argue that it is necessary to unpack the colonial, imperial, and othering underpinnings of ocean science and governance

at national and global levels. They draw attention to the "Western" scientific and legal frameworks on which the International Seabed Authority and national ocean governance in South Africa are based, and demand to decolonize both. Sacedon et al. (2025) address the question of unpacking and integrating knowledge by drawing attention to the feeling of discomfort that academics may experience at the "cultural interface," when engaging with diverse and alternate knowledges, including with First Nations and Indigenous Communities. They identify "fragility and guilt, helplessness, fear, ignorance, shame, challenged conceptions of time, and finally connection and relationality" (Sacedon et al., 2025, p. 1) as common themes and argue for more "reflection, learning, reckoning with historical wrongs and challenging hegemonic knowledge and politics" (Sacedon et al., 2025, p. 21) and respective time in the research process. From an institutional perspective, Brunnström et al. (2025) examine how universities can enhance their societal impact by developing new organizational models that integrate research, education, and collaboration with societal stakeholders. They compare two transdisciplinary centres—the Centre for Sea and Society at the University of Gothenburg, Sweden, and the Center for Ocean and Society at Kiel University, Germany—and suggest integrating "policy and institution-building activities" to the four societal interaction activities proposed by Hughes and Kitson (2012) to advance academic expertise on ocean issues and achieve the respective SDGs.

3. Conclusion

The oceans are spaces of exceptional relevance for humankind, but in these extraordinary times of polycrisis, environmental concerns receive less attention in policy-making. This also affects knowledge production in the field of ocean governance, which has already had to cope with limited financial resources, weak long-term planning, increasing polarization, and limited means to integrate diverse and alternative knowledges. While the contributions to this thematic issue often exemplify a weak status quo of how knowledge integration is practised in the context of ocean governance, they also provide novel insights on how this can be improved. Foremost, they stress that knowledge integration needs to be acknowledged as starting in the inner circles of science and political action is needed to address the substantial challenges related to complex coordination efforts but also funding issues. The insights presented show that the goal of advancing knowledge integration in ocean governance is not a sure-fire success, but requires much more effort, both scientifically and politically.

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Conflict of Interests

The authors declare no conflict of interests.

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ARTICLE

Epistemic Oscillation: Living With Ocean Risks

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Abstract

The year 2024 marks two decades since the Indian Ocean tsunami, known as the Boxing Day catastrophe, which far surpassed other devastating geological events of the 21st-century on humankind. Paradoxically, the epitome of tsunamis carries regenerative agency. It moves science and technologies across territories, proliferates knowledge production, and boosts innovations of warning systems as a critical part of ocean risk governance. In many cases, humans gradually distanced themselves from memories of past events due to the "high risk and low return period" of events. Through diverse risk perceptions, cultures, and beliefs, coupled with rapid human mobilities, the once proliferated knowledge could also be unlearned and forgotten. When knowledge on tsunamis is scarce or about to become extinct, no earthly process greater than tsunamis could bring back and sustain such knowledge. Like tsunami waves, this article argues that knowledge also refracts and oscillates. This article proposes epistemic oscillation as a conceptual lens as one of the ways to understand complex human and non-human entanglements, highlighting humans' dependent relations to geological dynamics, using the cases of the Palu 2018 tsunami as a testbed. By doing so, the article also argues that such lenses are useful in tracing the importance of understanding ambiguities in tsunami risk governance. By deploying an affective turn to ocean materialities and micropolitics as research methods, this article proposes alternative ways to unfold the multiplicities of social and geological realities and epistemic mobilities in the hyper-complex challenges of knowledge integration and ocean risk governance.

Keywords

1. Introduction

The proliferation of knowledge after catastrophic oceanic events is fascinating to delve into. This article, in particular, is less interested in how knowledge is accumulated, and rather more in what ways tsunamis can potentially uncover or even further enforce their regenerative agency in bringing more diverse knowledge and sense-making realms to the surface. This article proposes epistemic oscillation as a conceptual lens to understand complex human and non-human entanglements, highlighting humans' dependent relations to geological dynamics, using the case of the Palu 2018 tsunami as a brief testbed. By doing so, the article also argues that such a lens is useful to trace the importance of understanding ambiguities in tsunami risk governance. By deploying an affective turn to ocean materialities and micropolitics as research methods, this article proposes alternative ways to unfold the multiplicities of social and geological realities and epistemic mobilities in the hyper-complex challenges of knowledge integration, ocean risk governance, and with hyper-objects like tsunamis. This article intends to address the question of not merely how different interests, disciplines, and political dimensions are connected or integrated, but rather examines the interwoven relations of knowledge-making with earth processes, which offers an alternative way of understanding and governing the risks extended by our oceans.

The article, therefore, highlights the importance of the onto-epistemological analysis of human and non-human relations, where we can benefit from the lenses of new materialism and assemblage thinking. This means that the article does not intend to disregard the epistemic framing of analysis, but rather moves slightly away from the traditions of human-centric and social constructivism approaches while sharing a fair share with the ontologies of tsunamis. The concept of epistemic oscillation is a lens and, simultaneously, a result of moving away from such merely anthropocentric arguments. By engaging with the ontology of tsunami waves—specifically studies on the physical nature of tsunami waves and oscillation characteristics—and translating the waves into the epistemic contexts, I argue in this article that tensions, power asymmetries, and issues on sustainability carried by the proliferation of knowledge can be better understood. I posit that epistemic oscillation as a conceptual lens provides us with an alternative angle to better comprehend the social productions of tsunamis that frame why certain societies lack preparedness or why certain interventions or warning system technologies tend to fail in the longer term (UNDRR & UNESCO IOC, 2019). Knowledge proliferates, travels, saturates, and later continuously *oscillates* through more upcoming events and is perpetrated by the many local and trans-local situatedness. This does not necessarily go in line with the logic of coastal development and disaster risk interventions. I argue that such patterns resonate with how tsunami waves physically oscillate, a back-and-forth motion from one extreme to another (e.g., Satake & Shimazaki, 1988).

The remainder of the article is divided into three parts. First, it probes the tsunami's regenerative capacities amid the current mainstream approach of studies on ocean risk governance and knowledge-making. As a gift, tsunami resurface what might be treasures for humankind. An illustrated vignette of a nearly extinct species that was "saved" by the waves is provided, which encourages readers to engage more with the idea of this article. The second part elaborates on the concept of epistemic oscillation (Rafliana, 2024) while scratching the surface of the methodological possibilities through the lens of new materialism and assemblage thinking. While doing so, this second part provides case studies from a palaeotsunami study and tsunami survivor stories in Palu, Central Sulawesi, Indonesia. Here, readers are invited to observe the diverse entities across temporalities that are brought together as assemblages of knowledge that entangle with

earthly events Finally, in the discussion section, the article posits arguments that instead of preserving the problematic anthropocentric divides, one could look at the value of ambiguities and further consider the importance of tsunamis, rather than merely posing them as threats and danger. By looking at the importance of tsunamis and appreciating the entangled effects and ambiguities, one might uncover the power tensions behind knowledge-making and rebuild more symmetrical human and non-human relationships in the knowledge-making processes that are essential in rethinking ocean governance.

The development of the proposed concept of epistemic oscillation (elaborated in Section 3) is intricately linked to the micropolitics of research methods and analysis while appreciating the inspiration both from new materialism and assemblage thinking and, importantly, from a conversation with a Japanese scholar (explained in Section 2). The discussion highlighted the quest for current research related to the usefulness of tsunamis, picking up from the 2011 Great East tsunami in Japan. On the other hand, new materialism' propositions lean towards appreciating the non-linear, uneven, and continuously changing material world, where the agency of entities co-produces the social world, be it human or non-human (Fox & Alldred, 2016).

I realized that looking at the complex entanglements of humans and their knowledge, tsunamis and warning system technologies extend beyond the constraints of my positionality. My upbringing in the western territory of Indonesia as a female social scientist working mostly in the male-dominated environment of natural scientists, engineers, and disaster risk reduction, and living almost constantly in an area where earthquakes and tsunamis are part of the social-making, are among the traits that shape the micropolitics in this research. They also affect how I work on the research questions while trying to think differently in an attempt to suggest alternative ways of thinking through/with tsunamis and ocean governance.

New materialism as an approach would encourage looking at both micropolitics and tensions in the research subject, but also the micropolitics of the research itself (Fox & Alldred, 2016). As many were transformed by the tsunami event in 2004, I also experienced how tsunamis have contributed significantly to my personal and professional trajectories. I appreciate this as a privilege connecting me with other scientists, events, and conventions, leading me to many experimental thinking processes. This privilege became part of my micropolitics to conduct this research and helped enable me to see knowledge integrations differently, i.e., when knowledge integrates with earthly forces.

I would not say that new materialism as an analytical lens is the single and best answer to understanding the ever-growing complexities of the world and earth-beings. New materialism at least offers a way of understanding such complexities. My political role in this research, or the micropolitics of research, is to admit the limitations in understanding the complexities of human and non-human interactions and even more the limitations of humans to comprehend the earth's behaviours. It is also suggesting to stand against the sole domination of language and interpretations of the earth as a being, or at least to understand that human (limited) interpretations come with consequences. Such an approach potentially provides additional insights and illustrations that go beyond what already exists in many publications, particularly in terms of thinking about alternative methods of appreciating and living with tsunamis. As a person entangled with the topic of tsunamis during the past two decades, I can say that the more I follow tsunami events, the more the waves shape me, the way they behave, and offer uncertainties, which encouraged me to speak on the importance of the waves as many of our ancestors had already advocated, beyond the narrated threats and

hazards. In this argument, we shall proceed to discuss the generative capacities brought by non-human beings such as tsunamis.

2. The Generative Capacities of Tsunamis

Knowledge has always been appreciated as a determinant factor in governing the ocean (Hornidge et al., 2023) and reducing ocean-related disaster risks. Such determinacy affects and has been affected, among others, by the foreseen outcomes of the UN Decade of Ocean Science for Sustainable Development: a clean ocean, a healthy and resilient ocean, a productive ocean, a predicted ocean, a safe ocean, an accessible ocean, and lastly, an inspiring and engaging ocean (UNESCO, n.d.). As much as the vision and mission of the UN Decade of Ocean Science focus on ocean matters, the main actors and benefactors defined are humans and their well-being, and the ocean is narrated as the "Ocean We Want."

The Tsunami Ready program and the Safe Ocean Laboratory event are among the championing targets in achieving safe ocean outcomes. The topics related to the mitigation and preparedness of communities for ocean hazards, such as tsunamis, were facilitated by the Intergovernmental Oceanography Commission under the auspices of the UNESCO Tsunami Ready program. Under the UN Ocean Decade, the UNESCO Tsunami Unit has been spearheading the initiative to achieve the target of "100% of at-risk communities recognized Tsunami Ready by 2030s" by creating a UN Decade tsunami ready (UNESCO 2022), which has the goal of propelling efforts in community preparedness across the global ocean.

What I would like to highlight is not necessarily the question of how to achieve such an ambitious status of 100% of communities being prepared for any upcoming tsunamis by 2030. The promising intentions and good deeds of such programs have already been assessed elsewhere (Sakya et al., 2023). What interests me is how asymmetrical power relations are mediated, amplifying divides between humans and non-humans—including ocean matters—through the ways in which oceans are expected to behave and serve human interests. There were exponential changes in tsunami knowledge from merely a "harbour wave" experienced by fisherfolks and coastal dwellers to an imminent threat and hazard, exposing human vulnerability and capacities to oceanic risks. Such delineations are expressed, for example, in the Tsunami Glossary published by UNESCO IOC in 2019, which refers to tsunami warnings as "an alert, usually issued by a National Tsunami Warning Centre (NTWC) to indicate that a tsunami hazard is expected and imminent" (UNESCO IOC, 2019, p. 36). Such understanding propels social movements, governance, and the technicalization of humans against tsunami waves through advancements in science. Knowledge about the waves has created affordances to shape new institutional functions, delineating what is hazardous (Rahayu & Comfort, 2023) and what is not, who gets to delineate, issues of authority and sovereignty, and more.

I will now address what is meant by tsunami affordance. I learned an interesting and I gained valuable insights through a communication exchange in 2022 about my doctoral research topic with Japanese scientist Dr. Noriko Uchida. Dr. Uchida is an ecosystem resilience specialist from Tohoku University Japan, whose appreciation of human and non-human entanglements sheds light on the active role played by these troubled waves in changing lands and environments. Dr. Uchida pointed out that the Great Tsunami that hit Japan in 2011 had invigorated some endangered species, e.g., *Monochoria korsakowii*, locally known as mizuaoi, which is a weed-like plant from a hyacinth family. Weeds are used by Japanese coastal dwellers for household purposes, to make textiles, weave into ropes, and are also offered at shrine rituals. These species

once played an important role in the life of coastal dwellers along the Sanriku area and other Japanese coasts. The weed was once tied very closely to human existence. The massive energy that the tsunami brought during the 2011 event was enough to excavate the remaining endangered marsh plants that once threatened to become extinct due to human activities and a low genetic diversity level (Chen et al., 2023). As an ecologist, Dr. Uchida observes this phenomenon as the positive effect of tsunamis. The resurgence of this particular species showed that tsunamis are beyond hazards and threats to nature, as they can simultaneously reveal the threats humans pose to other species. Despite their volatility, not many studies have been conducted on the usefulness of tsunamis. Dr. Uchida explained that it is much easier for ecological scientists to think about how certain earth behaviours treat ecologies and surrounding environments. However, it is not easy to fathom that the waves could have positive effects on humans. Now that tsunamis are conceptualized basically as oceanic beasts, the phenomena have become gravely reduced into terminologies of threats and hazards. This is an interesting paradox, where such a reductionist view of the non-human entities would come at a price (van Loon, 2019).

The price one has to pay when relying solely on social constructions of the world might be the failure to grasp earth-human-technology relationships beyond how humans know what humans know. Keller (2019) agreed with Whitehead's arguments (Whitehead, 1978, as cited in Keller, 2019, p. 151): "[If] we desire a record of uninterpreted experience, we must ask a stone to record its autobiography. Every scientific memoir in its record of the 'facts' is shot, through and through, with interpretations." This is an almost cynical assumption that stones must be asked to record its being-ness cost as the price of ignoring the agency of rocks and hence soils, tsunami waves, earthquakes, and other relevant natural processes that shape the way humans live. In the next section, I will use an example of a method of interpreting earthly processes through a palaeotsunami by highlighting research on understanding past or prehistoric tsunami events from the materialities of littoral spaces, sands, sediments, and fossils. If Whitehead's statement is taken as the only truth, which seems to be what Keller is attempting, not only do we risk failing to make space for the ontology of tsunami deposits, but in this case, we also risk failing to express their agency in terms of keeping stories of past tsunami events through its layers of sands and preserving the histories of events. It also challenges the possibility of (inter)transdisciplinary science remedying the limitations of interpretations.

To trace studies related to tsunamis and its onto-epistemology, the current trend is not very promising. Social studies on tsunamis predominantly descend from natural science and engineering. These two science disciplines were responsible for announcing tsunamis as a scientific terminology and as a science during the International Union of Geodesy and Geophysics convention in 1960 in Helsinki. Years after the establishment of tsunamis as a science, many followed by empathising with the social dimensions of tsunamis, in which studies highlighted vulnerable communities. Studies on social vulnerabilities emerged in the 1990s. As research on tsunamis exponentially grew after the 2004 Indian Ocean event, studies on the social dimensions of tsunamis also proliferated, of which topics of research were advanced around economic livelihoods, risk perceptions, impacts of tsunamis on human health, reproduction, education, and policy implications. This comes in light of the ever-changing coastal regions, with the increase of human mobilities, and at the same time segregation of the many populations which, in turn, increases their vulnerabilities. These elements of humans and their environments are factored into the current mainstream of risk analysis and risk reduction perspectives. In this sense, social science has recently emerged even more prominently.

The University of Delaware is an example of social science leadership in the realm of disaster risks, claimed as the first research centre for social studies on disasters that was established in 1963 (Cox et al., 2019). The main aim of the centre is to provide knowledge for better risk management planning. However, the departure of collective social thoughts was in line with those of natural science, i.e., how to address hazards and alleviate vulnerabilities. Similar to the domain of sociology, much is put into the attention on policy processes and post-disaster interventions that include social issues of disaster victims and efforts to restore their social lives after a calamity runs its toll (Hettige, 2023) and less on, for example, the entanglements of the social dimensions of technologies, and warning systems. Sociology studies in tsunamis are far scarcer, and from the few that do exist, most also discuss studies with similar anthropocentric views. Nevertheless, this in itself is also evidence of the regenerative capacities of tsunamis beyond the metaphoric sense; the growth of multi-disciplines, social, natural, engineering, and more interdisciplinary approaches around the topic follow the recurrent of tsunami events.

Without challenging oneself on the genealogy of disaster studies, these approaches, I argue, bear consequences of technicalization—or, as Li (2007) terms it, rendering technical and compartmentalizing that are descendants of postcolonial practices of knowledge. Those in the darkness of knowing should be enlightened, and those vulnerable to tsunami risks should be prepared. An asymmetrical approach at the same time brings in questions of reciprocities, power asymmetries, inclusions, exclusions, and claim-making. The manner in which tsunamis are understood scientifically as hazardous speaks to reconstruction projects after an event, in which the patterns of responses had forcibly prevented coastal dwellers to re-establish their livelihoods by planning ahead and moving them to "safe zones" (Clark, 2010), creating what locals call "the second tsunami" or the "real tsunami" (Darmanto & Rafliana, 2023). Through the generative capacities of tsunamis, one could perhaps look at alternative ways of appreciating, understanding, and living with the waves.

Some studies from a different lens are likely among the most transdisciplinary endeavours by individual social scientists that emerged after the 2004 tsunami, following a series of consecutive tsunami events worldwide. These studies examine the more intimately entangled relationship between humans and non-humans. While working around the notions of human vulnerability, critical geographer Nigel Clark (2007) wrote a paper on the generosity of the volatile earth, responding to the Indian Ocean tsunami in 2004. Anthropologist Stefan Helmreich (2006) also reported his conversations on tsunami science with Indian anthropologist Amitav Gosh freshly after the 2004 tsunami and ethnographic observation of a scientific meeting in India in his paper on the collision of political and geological time of the tsunami. In his report, he underlined the uncertainties and agential forces of the tsunami waves that overwhelmed science and its capacity to understand the 2004 event. Later, in 2023, Helmreich published *A Book of Waves* and set under the spotlight the non-human agency of waves in many forms as means, perhaps with noble and ambitious intentions, to assess science and humanity. These approaches include the non-human perspective, in which one could expand the perspective towards the horizons and, at the same time, include oneself in the dialogue in much more reflective ways.

Following the Chilean tsunami in 2010, urban anthropologist Ignacio Farías took the science and technology studies stance in urban studies, underlying tsunami waves as crucial actors and as important entities of coastal urban assemblages (Farías, 2014). Farías reminded us that humans learned about tectonic and tsunami forces for generations and arranged their lives around and co-existed with these forces. However, similar to Helmreich, it seems that there is an enormous capacity of tsunamis to overwhelm knowledge,

which, in most cases, continuously fails humans in attempting to recognise and deal with the waves (Farías, 2014). This was precisely the reason to position tsunamis as the enemy. The ways tsunamis are posited may conclude how humans deal with tsunamis through convincing advancements in warning system technologies or with the International Tsunami Ready Programme. Perhaps what is needed instead are more attempts to challenge these posits, inspired by the many scholars previously mentioned. A path in which science and technology studies could offer an experimental route to revisit contemporary ways of thinking and knowing about tsunamis, exploring how humans create technologies that are also entangled with their social consequences, all while placing a respectful spotlight on the waves beyond their merely hazardous nature. Clark, in his book *Inhuman Nature: Sociable Life on a Dynamic Planet*, wrote of the great challenges of such paths:

> Whatever disciplinary division endure in the corridors of learning, research, and policy-making, nearly everybody these days agrees that it makes good sense to look at the dynamic of the social and physical worlds together. It is much harder to reach an agreement about how best to do this, where to start, what weighting to give the respective forces and processes, and how to bring very different elements into the same storyline. It's difficult enough for social scientists, humanities scholars or earth scientists to come to a consensus among themselves, let alone to reach across meta-disciplinary divides—and a whole world of jostling interests and values—to attain some shared planetary vision. (Clark, 2010, p. 3)

This article is an attempt to experiment with the concept of epistemic oscillation, following the thought processes of the above-mentioned scholars, who, one way or another, I would argue, also took agency in oscillating knowledge after different tsunami events, be it the Indian Ocean 2004, Chile 2010, or other events, which further inspired this article and many others who study the social lens of tsunami science.

3. Resonating Tsunami Waves: Epistemic Oscillation

A few months before the Indian Ocean tsunami in 2004, I was already starting my early career in coastal management and coral reef rehabilitation. Of course, tsunamis were part of the events discussed as being among the ocean's threats to coastal dwellers. Stories on past tsunami events were shared in conversations in places I visited and with communities I engaged with, such as the 1992 tsunami in Maumere Flores, the 1994 tsunami in Biak Papua, and several others. However, not much tsunami awareness and public education was available during the time, particularly in many tsunami-exposed littoral spaces in Indonesia. I was responsible for developing a children's school book series on coral reef management and coastal conservation. I remember that tsunami risks were not part of the main concerns that the book addressed.

The 26 December 2004 Indian Ocean tsunami shocked the world beyond the exposed areas, impacting dwellers, tourists, scientists, humanitarian assistance offices, business and private sectors, the UN, high-ranking officials, local governments, and military forces. The magnitude of the disaster was among the most transboundary-devastating events in contemporary human history. This single tsunami event caused approximately 230,000 lives to be lost with a wide range of damage in 15 countries (Suppasri et al., 2012). The event had promulgated an exponentially high number of publications, reports, and scientific papers related to tsunamis. Synolakis and Bernard (2006) highlighted that tsunami studies before 2004 emphasized the hydrodynamic characteristics of the waves, with less sophisticated tsunami source modelling and a grave lack of understanding of the hazards that might pose a threat towards the Indian Ocean rim. Some of the

pre-existing scientific knowledge was regenerated by the 2004 Indian Ocean tsunami and was then re-invigorated or even unlearned due to the findings and studies of the aftermath.

Through the Publish or Perish engine search, out of approximately 1,000 papers, books, and reports (excluding media coverage) published in the last 75 years, i.e., from 1946 to June 2024, only about 10% were published before 2004. The topics grew significantly after the 2004 Indian Ocean tsunami to include a broad range from hazard and risk assessments and forecasting, tsunami modelling, warning systems, mitigation, relief, and relocation to studies on tsunami risk perception, ethnosciences of tsunamis, and local knowledge of hotel management and tourism industries related to tsunami risks, and to environmental changes and issues on sustainability and risk governance. Tsunami sciences were more strongly repurposed from understanding the wave characteristics to understanding human responses to natural and technological warnings toward saving lives (Eddie N. Bernard, personal communication, 2021). This was even more so after the Great East Japan earthquake and tsunami in 2011, a year in which there were 200 publications. Despite a relatively smaller number of events that followed, more than 800 papers were published from 2012 to 2024 on the 2011 tsunami event alone. Similar interesting patterns have emerged in other historical events, affecting local and trans-local enlightenment trajectories in understanding the world, such as learning from the Lisbon 1755 event and Japan Sanriku 1896 and 1933 events (e.g., Baptista et al., 1998; Shuto & Fujima, 2009; Trethewey, 2020).

Oscillation, borrowing the terminology from physical science and in its most literal sense, means the back-and-forth, swinging pendulum-like motions that apply to different forms of materials, including water, ocean waves, and tsunamis. Tsunami oscillation is commonly recognized as a terminology in tsunami science, referring, for example, to the resonance of tsunami wave amplitudes in harbours and bays. The waves have to be "excited" to oscillate, be it by vertical displacement of the water column due to earth fault ruptures or other material disturbances such as underwater landslides, volcanic eruptions, and many more (Tetsuo, 1984; Jia, 2017; Lepelletier, 1981). The wave heights increase rapidly to evolve and decrease over time and distance.

Thinking about ocean waves, oscillations, and how they affect social changes is part of the affect and ontology turn in social science. Helmreich discussed social oscillations in *A Book of Waves*. He expedited that ocean waves, winds, rainfalls, and currents shape the structure of coastlines (Helmreich, 2023). So, discussing epistemic oscillations and aligning the ideas of Helmreich is not something new. The newness of this concept of epistemic oscillation that I would like to emphasize here is the prerequisite roles of tsunamis in the social production of knowledge, particularly scientific knowledge. Tsunamis are not only possible or likely to shape and advance scientific knowledge and create social change: they must happen, and thus, tsunamis are vital. This also emphasizes the importance of both ethnoscience and modern sciences in respecting earth systems where earthquakes and tsunamis are important heartbeats, a perspective which will have different meanings and interpretations for science into policies and actions.

When observing the way tsunami knowledge and science proliferate and advance, there are dire similarities within which the social productions of knowledge mimic tsunami oscillations, where engagements of science, development of laboratories, and exchanges of scientific findings escalate and are excited by tsunami events. Humans can only do so much in sustaining knowledge and science before such knowledge becomes saturated and loses its pace until another tsunami event occurs: the greater the magnitude, the greater the impacts. It makes sense to follow the rhythms of oscillating ocean waves and acknowledge the agency of tsunami

waves in the production processes of knowledge and science as they are further developed and sustained. Particularly in the case of the social production of tsunami science, the happenings of tsunamis and their entanglements of different human and non-human entities are indispensable and are almost a prerequisite.

To implement the concept of epistemic oscillation, let us now move to the case of Palu, an urban coast in Central Sulawesi, Indonesia, that has been shaped by centuries of tsunami events for its placemaking. The territory is set upon complex junctions of multiple earth plates and fault systems (Socquet et al., 2006, as cited in Putra et al., 2023). The areas were severely impacted by earthquakes, colossal liquefaction, underwater landslides, and massive tsunami waves on 28 September 2018 that took at least 1,100 lives (Triyanti et al., 2023). However, historical records, which are available only since the early 1900s, show that Palu is also among the territories where the reoccurrence of tsunamis is exceptionally frequent (1927, 1938, 1968, and 1996; Putra et al., 2023).

A first-ever study on the geological evidence of past tsunamis, known as palaeotsunami studies, in this area was conducted a few years later and led by Putra et al. (2023). The study documented layers of coastal soils excavated approximately 200 m from the tip of the Palu Bay coast, digging around 100 cm deep. This captured layers of distinct soil in different depths which indicated at least three tsunami events that occurred in the past several centuries using methods of carbon dating to identify the age of the layers. The layers serve like a photo album of past historical events: the first layer was found at a depth of around 80 cm (suggesting a tsunami around 1869), the second was around 60 m (1755), and the third was around 30 cm (1657). These three layers of soil have a lighter brown colour compared to the adjacent soil layers above and below. In addition, the layers showed a larger number of damaged foraminifera specimens, indicating the energy that the past tsunamis had brought while surging inland and thus bringing these species along as the tsunami exposed sands and soils that were gradually buried by new layers of soils (Figure 1).

The earth's memories, later interpreted through palaeotsunami studies, and human memories of tsunamis were brought together by the Palu 2018 event. Tsunamis became a "gift" when human memories were not capable of preserving events centuries back, as the palaeotsunami soils would. Indigenous communities preserve memories of past tsunamis and liquefaction and reside in the suburban and rural villages of Donggala, adjacent to Palu Bay. This is, of course, not without a rational logic, since humans retreated due to the devastating impacts of tsunamis on the livelihoods of coastal dwellers. Such a retreat also comes with new vulnerability, as past events went unlearned due to high human mobility.

On the other hand, although the recurrence of past events seems to be quite frequent, trans-generational knowledge was also not necessarily passed through. The memories of more recent tsunamis, e.g., 1927, 1938, and 1968 (Putra et al., 2023; UN for Disaster Risk Reduction, 2019), that affected the areas were kept among a few survivors who were rural dwellers. The more temporally distant the event, the more it is forgotten. As such, epistemic oscillation also applied to the temporality of the case, where the knowledge and response capacity in 2018, at least to several Indigenous dwellers, in many ways resonated from memories of the past, even from the 1938 event.

An elder in one of the villages was a survivor of the 1938, 1968, and 2018 tsunami (UNDRR & UNESCO IOC, 2019). In an interview, he passed a story from his parents on where to go if there were mishaps occurring. The word tsunami was not a known terminology at the time and locals called the event *Bombatalu*, which
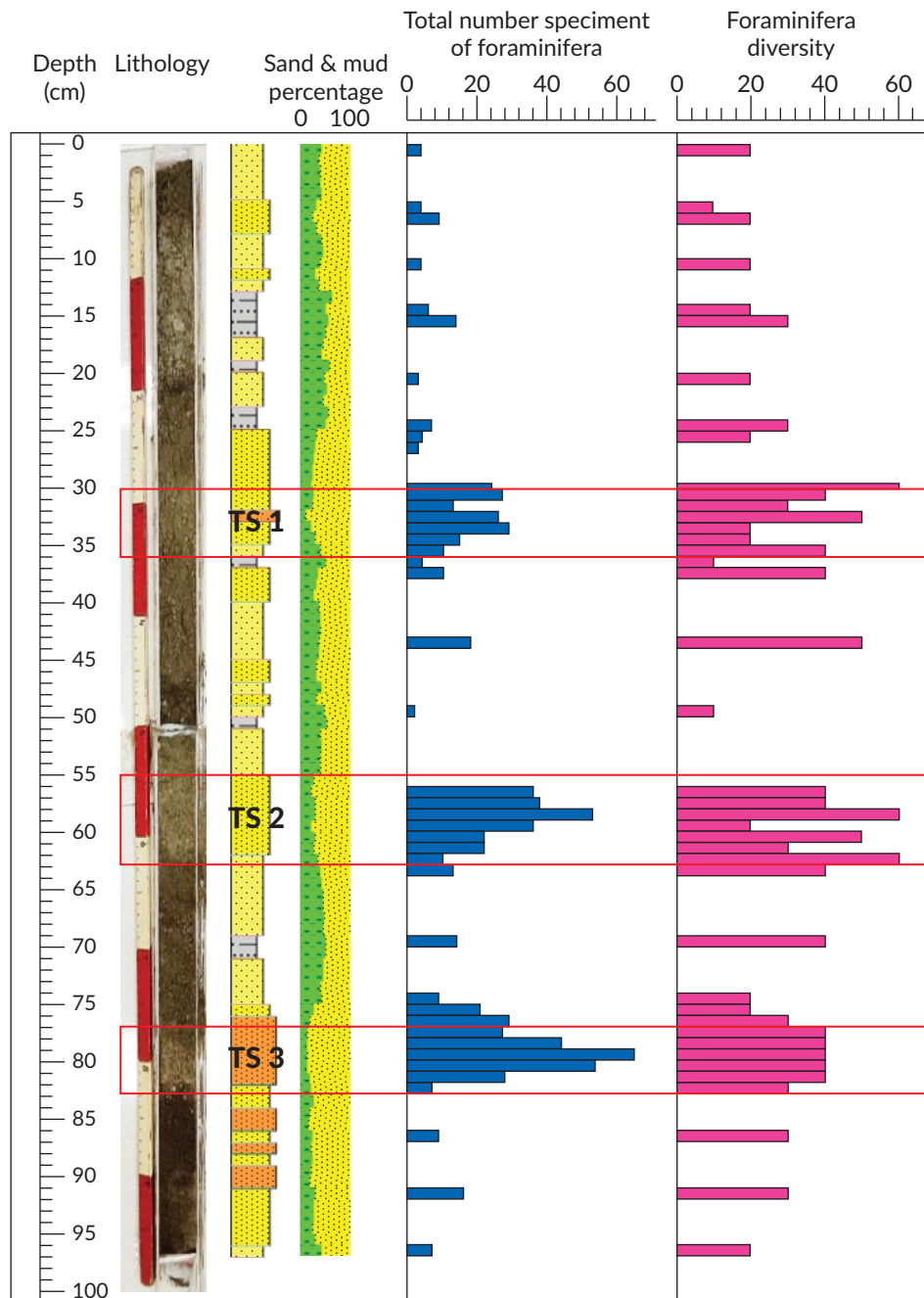
Figure 1. The layers of tsunami sand deposits in Palu Bay, Indonesia. Note: TS1, TS2, and TS3 are palaeotsunami layers (tsunamis that occurred in prehistoric times). Source: Putra et al. (2023, p. 490).

means the three waves. Knowledge about the waves materialized into ethnoscience, where the elder shared that his ancestors knew where to go and which hills to avoid from landslides and collateral catastrophes. However, this knowledge was not necessarily transferred to younger generations, due to certain customs and taboos forbidding such stories to be told or passed along. Even the wife of this elder did not know about the 1938 event before 2018 happened when her husband finally shared his knowledge about his tsunami history. The tsunami event brought his preserved memories back to life.

Modern science grew rapidly after the 2004 Indian Ocean tsunami, which affected the far west coasts of Indonesia. Education interventions reached Palu and were introduced by local non-government agencies, the local government, and scientists. However, the education messages miscalculated the possibility of the 2018 scenario and were translated much differently. It is fair to conclude that modern knowledge and technological fixes found their limits in preventing fatalities. Communities complied with the tsunami risk assessment and tsunami drill training scenario about six years before the 2018 event. The scenario assumed a 15-minute lead time to reach a safe place. The 15-minute lead time was merely among the many possible tsunami scenarios applicable to the region's context, and unfortunately was not the case when the 2018 event occurred. The possibility of moderate earthquake-inducing underwater landslides was not factored into the rather deterministic scenario upon which risk reduction strategies, established several years earlier, were built. The tsunami turned quite differently and caught many by surprise with less than five minutes of arrival after the massive earthquake, leaving an impossibly short amount of time to run to safe grounds as instructed (UN for Disaster Risk Reduction, 2019).

These experiences and knowledge travel back and forth, oscillating across different territories, temporalities, conventions, and epistemic groups, from scientific papers to preparedness and countermeasures as well as mitigation efforts. In certain periods of "peace," collective knowledge potentially diminishes. Epistemic oscillations collide with the inhuman nature of earth forces which humans tend to try to control but are actually dragged into, in back-and-forth motions of learning and forgetting, of constructing and reducing meanings of the waves, of dispersions, dissemination and saturations of social processes, of the excitement of "new" findings, confusions, and negotiations, of the emergence of "new power," resistances, domination, and dependencies. All of these are afforded and, at the same time, constrained by non-human forces: earthquakes, tsunamis, and earthly processes. They are also afforded by the materiality of other non-human forms: observation instruments, warning systems, detection devices, and other technological artefacts.

4. Conclusion

Moving in and out from a human-centric analysis of knowledge-making through discourses to attempting to centre-stage the earthly being is admittedly intricate. It follows with an abyss of temporal and spatial differences applied to geologies and humans in an effort to examine alternatives of dualities in the analysis through new materialism and assemblage ways of thinking. As the Great East Japan 2011 tsunami relived the important yet endangered species of mizuaoi in Japan, the Palu tsunami relived and revealed memories from both humans and the earth, demonstrating interdependency relations, or rather, human dependence toward earthly processes to allow growth and oscillations of knowledge. As such, tsunamis shall no longer merely be framed as a "hazard" or "threat," as tsunamis are beyond these misnomers. A possibility that Fox and Alldred (2016) elucidate is removing, or rather disassembling, the dualisms between the physical world of things and bodies and the realm of thoughts, social structures, and cultural products, as well as reassembling the diverse and overwhelming entities that accommodate realities independent from human thoughts or knowledge, while at the same time weaving in diverse, evolving, and socially constructed knowledge into a storyline. In doing so, analyzing the social intricacies behind scientific texts and technologies is to a greater extent possible, i.e., scrutinizing the transcendental behind (tsunami warning system) machines. Also, such a perspective will discuss the possibilities of understanding ambivalences and paradoxes, including gifts brought by natural forces. To take this further, we should explore the inseparable ambivalences as part of future research and policy agendas once we aim to better understand complex and cascading ocean risks.

The turn to new materialism is not objecting that humans operate through interpretations. It instead highlights the problems of the power of language and interpretations that are being scrutinized. For the palaeotsunami study, it is the power and (scientific) language used to interpret the meaning of these layers. The interpretation may be used to delineate hazardous areas due to the evidence of past tsunami events that are used as the foundation to regulate future ones. Once the hazard areas are delineated and legitimized, they become important information for tsunami risk reduction measures, but at the same time, they are prone to social tensions and contestations, where ports, dwellers, the tourism industry, businesses, and coastal inhabitants are convinced that they are now living with tsunami risks. I further argue the importance of understanding and empathizing with these paradoxes and ambiguities to develop, for example, more sensitive risk communication and many other uses.

Through a new materialism lens, the sociology of knowledge also lends a better and more reasonable understanding of tsunamis' important and generative roles and ontological features. Tsunamis are more than merely a construed "hazard," and I argue here that the narratives around tsunamis as such have grown to become more reductionist since human understanding about the waves through the sciences has proliferated, along with advancements in communication and transportation technologies, science infrastructures, and funding that allow a more thorough and deeper understanding of tsunami events.

Epistemic oscillations are where and when knowledge integrates with earth processes. Such proliferations are tied to the dynamics and happenings of earthquakes, tsunamis, volcanoes, and other so-called natural hazards. The ambiguities lie in what knowledge has been unlearned. Risk perceptions diminish when the earthly processes are felt or seen as distant, both spatially and temporally. This is the case for tsunamis, which have long return periods and carry many epistemic and ontological uncertainties. This means that uncertainties due to the limits of human knowledge and capacity to understand the earth's dynamics along with its geological and social complexities are important dimensions of governing risks (Triyanti et al., 2023). Ambiguities also lie in the interpretations of realities, which are often framed and accepted as truth. This comes with grave consequences, as illustrated in the Palu tsunami case.

Conflict of Interests

The author declares no conflict of interests.

Data Availability

The article includes data primarily from the author's doctoral monograph titled *Traveling Waves of Knowledge and Technology: the Indonesian Tsunami Warning System* (2024).

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ARTICLE

Disrupted Sand Flows, Artisanal Fishers, and the Making of Coastal Protection in Southern India

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Abstract

Flowing parallel to the sea, sand is subject to erosive, accretive, and extractive processes and is intertwined with the socio-ecological dynamics at the land–sea interface. Human interventions, climate change, and societal responses to it are constantly reshaping the morphology of coastal areas and thus disrupting sand flows, for example, through the construction of harbours or groins to prevent erosion. In this article, we ask how disrupted sand flows shape the interaction and social dynamics between different coastal actors in the making of coastal protection. Empirically, we ground our research in the Pondicherry region of southern India, characterised by a sandy morphology and numerous fishing communities. Building on the literature on "geosocialities," we argue that engaging with the materialities of ocean sand and the social implications of sediment loss for artisanal fishers is crucial to reducing maladaptation. Following sand as a non-human actor unravels the social entanglements with ocean sand that underpin the implementation of protective measures and that shape access to sandy beaches for artisanal fishers. By exploring these contestations, we show how the reclamation of sand through groins is embedded in unequal power relations over shrinking beaches. While migration to other sandy beaches becomes a necessary means of adaptation, this leads to local conflicts over coastal space. We conclude by highlighting the need to understand coastal adaptation as a geophysical and socially intertwined process, in which ocean sand must be critically considered for future adaptation strategies.

Keywords

artisanal fishers; climate change adaptation; coastal protection; fishing communities; geosocialities; India; maladaptation; sand resources

1. Introduction

As Jimi Hendrix (1967) poetically reflects on the transience of human endeavours, he notes that "castles made of sand fall into the sea eventually." While human constructions and monuments are of a very temporary or at least uncertain nature until consumed by the ocean, to continue the lyrical metaphor by Hendrix, the tidal forces of the sea that move coastal sands outlast but are not unaffected by such anthropogenic activities. Often overlooked, but ubiquitous, sand resources supplied by rivers and tidal currents sustain and help build coastal areas where more than a billion people live worldwide (Intergovernmental Panel on Climate Change [IPCC], 2019). The link between sand and climate change is significant but complex. On the mitigation side, the extraction of marine sand releases (directly) the greenhouse gases sequestered in the sediments (Sun et al., 2023), while the production of concrete releases (indirectly) huge quantities of CO_2 (United Nations Environment Programme [UNEP], 2022). On the adaptation side, as a key driver of geomorphological processes together with ocean currents, sand not only sustains livelihoods and the marine ecosystem but also protects coastlines that are increasingly vulnerable to the impacts of severe weather events (Pilkey et al., 2022).

Given this interconnectedness, looking at coastal sand resources provides an important entry point for understanding climate and coastal adaptation and protection not as something external "out there" we adapt to, but as (re)produced through our lived environments as part of the social and biophysical forces (Taylor, 2014). In the era of the Anthropocene, characterised by persistent human impacts on a planetary scale, it is imperative to focus more social research on the various entanglements with sand in the context of numerous human interventions, such as dredging of navigation channels, the sand extraction for land reclamation, or the construction of coastal defences (Gustafson, 2021; Hein & Hilder, 2023). The implementation of hard and static coastal protection measures to coastal hazards (e.g., seawalls or groins) not only often demand huge quantities of sand but also takes place in highly dynamic and contested coastal environments, where sand resources are crucial but largely overlooked in governance processes. As such, coastal adaptation interventions are common examples of shifting vulnerabilities, not least due to overlooked power relations that are reshaped by infrastructural and technical interventions and result in maladaptation (Eriksen et al., 2021; Schipper, 2020). Formerly and as this work shows, coastal measures to a large extent were referred to as coastal protection. While the measures often remain the same, funding and framing increasingly fall under coastal adaptation to climate change. However, in the literature, both terms are categorized as adaptation strategies (Mamo et al., 2022). Considering its multiple uses and functions for the marine ecosystem, sand in particular is situated in contested arenas with multiple actors (Jouffray et al., 2023; Lamb et al., 2019; Torres et al., 2017). Climate change and societal responses to it are constantly reshaping the morphology of coastal areas and thus affecting marine sand fluxes, for example through the construction of seawalls and groins to prevent erosion. However, the social implications of sand loss for coastal communities remain a conspicuous blind spot in both adaptation planning and governance of resources. This article aims to fill this gap and contribute to the body of work on "geosocialities" by showing how disrupted sand flows shape the making of coastal protection and hence adaptation outcomes.

In a specific context in India's south-eastern coast, the construction of a harbour interfered with the littoral drift that resulted in the loss of livelihoods for thousands of artisanal fisheries that depend on sandy beaches for boat parking and storage. The traditional fishing techniques of the many fishing communities in the area have evolved over centuries around the sandy beach ecosystem, which provides a variety of functions, from

maintaining fish habitats to providing space for boat parking. Access to sand and space for the seasonal beach formation is therefore critical to the livelihoods of fish workers who depend on sandy beaches to access the sea. In this article, we argue that the (re)distribution of ocean sand is embedded in unequal power relations that make some populations more vulnerable to climate and environmental change than others. More specifically, we focus our analysis on how the disruption of sand flow shapes the interaction and social dynamics between different coastal actors in the making of coastal protection and future adaptation strategies.

In answering this question, we explore the contestation and struggle over access to sandy beaches, which contribute to adaptation to coastal risk, and identify a vicious cycle of maladaptation (Barnett & O'Neill, 2010; Schipper, 2020). Empirically, we ground our research in a case study of the Pondicherry region of southern India, a coastal environment characterised by a sandy morphology and numerous fishing communities. We argue that it is crucial to engage with the materialities of ocean sand to understand the contexts of social vulnerability. Our analysis focuses on the disruption of sand flows caused by coastal infrastructures. To this end, human agency is understood as shared with other non-human actors, such as sand and ocean currents, that shape the world and human history (Latour, 2005; Sayes, 2014). The implementation and functionality of coastal infrastructure in turn is shaped by the interactions between humans and non-humans and is an inherently political process with competing interests (P. Harvey et al., 2016). By exploring these human–sand relations, this article contributes to the emerging scholarship on "geosocialities" (Carse & Lewis, 2017; Dawson, 2021; Palsson & Swanson, 2016), which aims to engage more with the materialities of ocean sand as a non-human force. Coastal adaptation strategies herein are understood as a geophysical but also socially entwined process upon which access to sand is contested. The article is structured as follows. We begin by bringing together the importance of sand in adaptation processes in terms of coastal hazards and adaptation measures, before engaging with the literature on "geosocialities" and sand as a non-human actor. From this, we derive our methodology, which guides our fieldwork on the Coromandel Coast in southern India. Tracing the sandy morphologies found there, we investigate the disrupted sand flows that have led to coastal erosion and the social implications for artisanal fishing communities. We find that the construction of groins, in particular, is embedded in a cycle of fish workers' protest, rock extraction, and the constant northward shift of erosion, leading to the construction of more groins. After making these human-sand entanglements explicit in the empirical case, the article concludes with a call to integrate shifting ocean sands into future adaptation policies to reduce the risk of maladaptation.

2. Why Does Sand Matter for Adaptation?

Contrary to the common perception that sand is abundant, sand resources are declining worldwide for several reasons. Sand is the second most consumed resource after water with the main uses being the construction sector and coastal development (UNEP, 2019). As the world's most in-demand construction material, sand is the main component of urban development and the physical backbone of the built environment (UNEP, 2019). Its extraction causes severe socio-environmental damage and political-economic frictions, especially along the world's coastlines (John, 2021). For example, the unprecedented demand for sand is fuelled by the expansion of ports and coastal cities through land reclamation or beach nourishment, leading to a "looming tragedy of the sand commons" (Torres et al., 2017, p. 970; UNEP, 2022). Especially, in countries of the so-called Global South the regulation and enforcement of laws to prevent illegal sand extraction operations is complicated because of limited resources and governance capacities to monitor affected sites (Rangel-Buitrago et al., 2023).

2.1. Diminishing Sand and Its Impact on Coastal Risk

Sand is essential not only for booming urbanisation, especially in coastal areas, but also for the marine ecosystem. With an ever-increasing demand as an aggregate in concrete and as a nourishment for beaches or hard infrastructure in the coastal environment, sand resources are becoming increasingly contested and depleted far beyond their replenishment rate (Rangel-Buitrago et al., 2023). In particular, coastal development and urbanisation contributed to an accelerated rate of sand extraction that far exceeds the supply from rivers, coastal dunes, and beaches. At the same time, maintaining sand resources as a coastal barrier may be the most cost-effective adaptation strategy against more frequent climate risks, such as cyclones or slow-onset risks, including coastal erosion and sea-level rise. For example, the costs of rebuilding infrastructure after coastal hazards (e.g., flooding) due to the loss of protective beaches do not outweigh the profits generated from extracted sand resources (Rangel-Buitrago et al., 2023). Sand acts as a natural buffer at the land–sea interface between the terrestrial and marine ecosystems, but also stabilises the coastline. As such, sand resources play a critical role in protecting land and property from coastal erosion and severe weather events.

Interventions that alter the flow of coastal sediments or extract sand resources are associated with the production of risks or disasters. Given the risk of sea level rise due to climate change, sandy coasts are particularly at risk in terms of the projected demand for sand resources (Jouffray et al., 2023). A coastline that has been lowered by mining is more vulnerable to sea-level rise and flooding. In addition to climate risks and coastal hazards, human activities such as sand mining in rivers for construction purposes or hydropower dams that prevent sand from reaching the coast are a major driver of coastal erosion (Zografos, 2017). Disrupted sediment flows from rivers accelerate erosion processes, threatening coastal infrastructure and assets (Jouffray et al., 2023; Rangel-Buitrago et al., 2023). Reduced shoreline stability also contributes to the vulnerability of coastal environments to storm surges, flooding, and sea level rise, the latter often leading to the salinisation of coastal aquifers. In southern India and Sri Lanka alike, for example, both sand depletion from dunes and reduced sediment replenishment from rivers have exacerbated the effects of the tsunami in 2004 (Namboothri et al., 2008).

2.2. Sand in Coastal Adaptation Strategies

The coastline is never fixed on a map but dynamic and in constant interaction through erosion and accretion. Therefore, beaches are rivers of sand that flow parallel to the coast. As such, many coastal adaptation measures, including the construction of seawalls or groin fields, interfere with the natural transport of sand caused by coastal morphodynamics including tidal currents, wave energy, wind, and sediment transport (Rangel-Buitrago et al., 2023). Interferences that alter the flow of sand result in changes to the coastal environment. For example, the construction of groins is likely to result in a large reduction of sand supply to adjacent beaches and dunes because they block the littoral drift (Sundar et al., 2021). Ironically, such structures are often perceived as protective by coastal communities, even though they disrupt sand flow and increase erosion up or down the coast (Klöck et al., 2022). The removal of beach sand then again increases the demand for coastal infrastructure such as groins, sandbags, or breakwaters. In addition, the future demand for aggregates is predicted to increase as climate change threatens coastal infrastructure (Torres et al., 2021). This, in turn, will require careful coastal adaptation planning to redirect investment in coastal infrastructure.

Whether triggered by a groin or a dam, the disruption of sand flow causes damage downstream, for example, in the form of increased erosion or loss of protective features, and thus increases the risk of maladaptation to climate change (Magnan et al., 2016; Sovacool et al., 2015). The unintended effects of adaptation measures are embodied in the concept of maladaptation understood as "actions or inactions that may lead to increased risk of adverse climate-related outcomes, increased vulnerability to climate change, or diminished welfare, now or in the future" (IPCC, 2014, p. 857). Other definitions address the wider underlying drivers of vulnerability which are conflicts, marginalization, or economic restructuring that are embedded in socio-environmental processes (Magnan et al., 2016). For the purpose of the argument made here, the notion of maladaptation points to the possibility that disrupted sand flow unintentionally may increase the vulnerability of other social groups. A case study examining (mal)adaptation in Ghana's Volta River Delta shows how climate policy discourses legitimise hard engineering measures to deal with coastal erosion in isolation from the social-economic activities (e.g., sand mining) that exacerbate maladaptation (Owusu-Daaku, 2017). The construction of a seawall, for example, may reduce exposure in the short term, but may ultimately have negative impacts due to a false sense of security or the loss of sediment that causes erosion beyond the spatial scale of the intervention (Grothmann & Patt, 2005; Table 1).

Although considered a soft measure, beach nourishment for land reclamation and beach restoration, which consumes large quantities of coastal sand, is another prominent strategy to counter sand erosion that is increasingly framed as climate adaptation (Qiu & Gopalakrishnan, 2018). To increase the width of a beach, large quantities of sand are added, mainly by dredging sand from nearshore or offshore borrow sites (Bisht, 2021). Often referred to as "building with nature" or categorised as a nature-based solution, beach nourishment is increasingly preferred to hard coastal infrastructure as it is comparatively less disruptive to natural sand flows. However, the seasonal (re)nourishment of beaches, such as on the luxury tourist island of Sylt in Germany, only periodically prevents erosion but requires the continuous relocation of sand and financial resources (Hinrichsen, 2009). The redistribution of sand resources thereby affects the marine ecosystem by shifting currents and changing wave patterns, resulting in habitat destruction or loss of biodiversity (de Schipper et al., 2021).

Table 1. Sand-dependent coastal adaptation strategies.

	Adaptation strategy	Sand use	Pitfalls
Coastal Risks: • Flooding • Sea-level rise • Erosion	Seawalls	Construction material	Interference with sand accretion and beach lowering
	Groinfields	Construction material and trapping of sediment transport	Downdrift erosion of adjacent beaches and livelihood impacts
	Beach nourishment	Offshore mining of sand deposits and relocation through dredging	Loss of marine habitat and seasonal erosion
	Artificial dune building	Fences to stimulate sand capture and planting of sand-trapping species	Regulate sand extraction and uninhabited areas
	Sandbagging	Mined with shovels from sourcing sites	Emergency measures and short duration

In the context of climate and environmental change, sand in its various functions and uses is at the very heart of coastal adaptation processes and coastal risk management measures (see overview Table 1). Coastal adaptation strategies within (sub)national institutional frameworks fail for a number of reasons (cultural, economic, or poor implementation). However, the critical role of ocean sand in coastal governance processes and the relationship between multiple dimensions of maladaptation is a major cause that remains unexplained in the literature. The ability to access, use, and relocate sand resources is crucial for adaptation strategies and overlapping climate-related and human-induced environmental risks potentially confound adaptation outcomes (Taylor, 2014; Work et al., 2018). Therefore, this article aims to address the aforementioned research gap by conceptually and empirically integrating a sand focus into coastal adaptation and governance processes to unravel how human–sand relations are intertwined with shifting vulnerabilities, social needs, and unequal power relations. To this end, the next step is to lay the conceptual groundwork by locating disrupted sand flows within the concept of "geosocialities." This means understanding sand as a non-human actor that, for example through coastal morphodynamics, is intertwined with the social process of adaptation to climate and environmental change.

3. Disrupted Sand Flows and Sand as a Non-human Actor

Climate change adaptation to date has primarily focused on a narrow range of economic and technological outcomes, lacking engagement with the materialities that shape social vulnerabilities, such as increased conflict over the resources needed to adapt (Juhola et al., 2016; Kuhl et al., 2020). Here we argue that the integration and analysis of disrupted sand flows and their embedding in the making of coastal governance is fundamental to the success of adaptation strategies of the various actors that shape environmental change in coastal environments. For this purpose, we engage with the notion of ocean sand as highlighted by Jouffray et al. (2023). The notion of ocean sand is used here to refer to sand from near and offshore deposits, including beaches, bays, lagoons, estuaries, tidal wetlands, and coastal quarries, thus recognising ocean sand as an "interconnected and dynamic complex social-ecological system at the land-sea interface" (Jouffray et al., 2023, p. 9). Focusing on ocean sand helps to grasp the broader context of its embeddedness beyond the technicalities of sand as a construction material, and thus allows us to think of sand as a non-human actor in the coastal environment. This is crucial because, as a non-human actor, sand actively shapes, for example, aquatic habitats and is a key entity of important geomorphological processes not least because of its supply from rivers and tidal currents that sustain liveable coastal areas.

Our understanding here is based on the assumption that human intentionality is not the only determinant of action but also non-human world-making entities such as sand and sediment (Dürbeck et al., 2015). Ocean sand is active in the sense that it is subject to natural and anthropogenic erosional and depositional processes at the coast, often driven by dynamic sediment transport. In other words, ocean sand has agency as an organism that makes workable the "living arrangements" upon which human interventions materialize and thus demonstrates that "making worlds is not limited to humans" (Tsing, 2015, p. 22). The focus of this article is on disrupted sand flows along the Coromandel Coast of southern India where ocean sand is mainly used by small-scale fishing communities (e.g., boat parking and fish drying) or tourist activities, and disruptions are caused by the construction of groins and seawalls to stabilise the coastline or to protect against coastal erosion and cyclones. The agency of fish workers thereby is part of the broader spectrum of non-human agencies (Sayes, 2014). Ruled by tides, waves, and currents, the movement of ocean sand expands and contracts beaches. The continuous erosion and accretion then influence the locations of

breaking waves. The formation of beaches thereby protects the coast by adapting to wave conditions. In other words, sand is readily exchanged by these morphodynamics, resulting in the formation of sandbars offshore or dunes onshore. However, the resulting seasonal currents and the uneven movement of billions of tonnes of sand per year make the coastline vulnerable to the disruption of sand flows (e.g., by seawalls), resulting in an imbalance of sediment within a given sediment cell (Ramesh et al., 2011). Also known as littoral cells, a sediment cell encompasses the intertidal and nearshore movement of sediment at the shore including zones of erosion, transport, and accretion (Herman & Zhang, 2015). Particularly along the Coromandel Coast, sediment cells can extend for hundreds of km, crossing politically determined state boundaries, as is the case between Pondicherry and Tamil Nadu, which share the same sediment cell. Surrounded by the state of Tamil Nadu, coastal disturbances in the territory of Pondicherry materialise across states due to a shared sediment budget. Thus, sand actively produces coastal space beyond state jurisdiction.

Conceptually, we engage with the growing literature on "geosocialities" (Palsson & Swanson, 2016; Yusoff, 2018), which builds on and extends the concept of the "social life of sediment." Broadly speaking, the term "geosociality" encompasses the society-nature entanglements of the geological and the social, as well as the ways in which "humans in specific localities perceive and make sense of the geophysical environment" (Flitner et al., 2018, p. 47). It thus encompasses the making of the meaning of adaption efforts that reshape coastal geomorphologies but also the actors (e.g., fishing communities or local authorities) who manage vulnerabilities associated with coastal hazards. More specifically, the concept of the "social life of sediment" suggests that social needs, values, and activities are intertwined with the movement, or the mere existence, of sediment (Parrinello & Kondolf, 2021). By drawing on sediment metabolism for urban political ecology, Gustafson (2021) showed how sediment dynamics are linked to power relations in the production of uneven geographies. For this work, power is understood as relational in the sense that power arises from making connections across space and is generated between humans and non-humans as actualised power (Latour, 2005; Müller, 2015). In the Anthropocene, characterised by human influence on a planetary scale, sediment requires greater attention in social enquiry, given the multiple ways in which human activities directly intervene in sediment movement, such as through dredging or construction projects. Deforestation, for example, leads to soil erosion, which increases the sediment load of rivers, which in turn causes flooding and the reshaping of the morphology of coastal areas (McNeill & Winiwarter, 2010).

While the "social life of sediment" concept is mainly applied to the alteration of sediment fluxes in rivers, this article investigates human–sand relations with the aim of extending it as an analytical tool for ocean sand. For example, coastal land loss due to sediment starvation has received little attention in the literature. Similarly, the role of sufficient sediment supply for coastal restoration remains largely under the radar of policy debates (Parrinello & Kondolf, 2021). Building on the "social life of sediment," the integration of ocean sand recognises its critical role and the linkages between sand extraction, either through mining protective features or by altering coastal morphodynamics (e.g., tidal currents), and coastal hazards such as erosion from flooding. It allows us to examine the relationship between people and sand, where livelihoods depend on active sand bodies that are intertwined with the functioning of the marine ecosystem. Ocean sand therefore has non-human agency and is intertwined with social practices, coastal spaces, and needs that cannot be separated from the processes of adaptation. In the vein of co-produced natures and societies in the Anthropocene, a focus on geosocialities seems timely, where humans themselves have become a geological force to which they are now adapting. Climate change itself shows "how dangerous geologic intimacies have long been in the houses and factories of Europeans—the glowing red coal fires entangled

with industrial capitalism and 'modern' life" (Palsson & Swanson, 2016, p. 153). Moreover, this argues for recognising non-humans as implicated in webs of world-making and overcoming environmental determinism. Such an approach is in line with current calls for research to focus on more than human sociality (Krøijer, 2021; Tsing, 2013) and the goal of investigating the intersections between life and non-life (Povinelli, 2016).

4. Methodology: Following Ocean Sand

The methodology underlying this article is derived from the conceptual underpinnings of a more-than-human approach and is inspired by studies that "follow-the-thing" (Appadurai, 1986; Cook, 2006; Haegele, 2024; D. Harvey, 1990; Marcus, 1995). However, rather than following sand as an object back to its origins, we follow sand in the regional context of the Union Territory of Pondicherry, a former French enclave, and Tamil Nadu along the Coromandel Coast in southern India. This method aims to unravel human–sand relations by following multiple sites, or in a more Marxist fashion, tearing aside the veil to expose power relations and reveal underlying vulnerabilities of coastal adaptation (Hulme, 2017). Previous studies have mainly uncovered social relations behind the veil of commodities to make non-human actors visible. In our case, instead, we follow sand not in the logic of sought-after construction material, but as a crucial "thing" in dealing with issues of coastal erosion and infrastructure and the sustenance of coastal communities. Using qualitative methods, including semi-structured interviews, informal discussions, and direct observation, we engage with a range of coastal actors and ground our research in the everyday situations of artisanal fishing communities. Through these methods, we aimed to understand their perspectives on sand, disappearing beaches, protective measures, and the causes of coastal erosion. We mainly asked the same open questions to the same actors but changed the framing of our questions with respect to other actors. Fieldwork was carried out on the Coromandel Coast, particularly in Pondicherry and neighbouring fishing villages, between October 2023 and March 2024 as part of a research fellowship at the French Institute of Pondicherry. In total, $n = 33$ semi-structured interviews were conducted with fishing communities but also NGOs, involved in coastal protection and beach restoration, scientists from the National Centre for Coastal Research, locals involved in tourism, and government authorities, including the Public Works Department, the Port Department, the Pondicherry Coastal Zone Management Authority, the Pondicherry Climate Change Cell, and the Fisheries Department. For detailed location, the fishing villages of Bommayiarpalayam and Pillaichavady were selected, both of which are critically affected by coastal erosion, frequent cyclones, and the ongoing construction works of groins and seawalls to prevent the loss of beach sand (Figure 1).

Bommayiarpalayam is in Tamil Nadu state, while Pillaichavady is divided between the state of Tamil Nadu and the Union Territory of Pondicherry (still called French Pillaichavady by the elders). Respondents were identified following human–sand interactions and snowball sampling techniques starting from the Pondicherry Harbour northwards. Interviews were recorded, in some cases translated from Tamil into English, and transcribed where possible. The data was supplemented by field notes and transect walks along the coast. The transcribed material, consisting of interviews, field notes, informal discussion, and relevant policy documents was then coded using ATLAS.ti. Codes were derived inductively in the process of identifying key themes by following ocean sand. Key themes include sand as an actor (e.g., littoral drift), hard infrastructures (e.g., harbour and groins), spatial implications for fish workers, as well as rock extraction for coastal protection and are illustrative of the quotations in the discussion section.

Figure 1. Map of the study area.

5. Results and Discussion

5.1. Disrupted Sand Flows Along the Coromandel

The city of Pondicherry and the state of Tamil Nadu are located on the south-eastern coast of India, which is characterised by extensive sandy beaches, dunes, and other coastal landforms such as lagoons, estuaries, mudflats, marshes, and deltas (Figure 1). About 100km south of Pondicherry lies the Cauvery Delta fed by the Cauvery River, which deposits large quantities of sand and silt, forming wide sandy beaches through the forces of the littoral drift. Dunes and beaches, which are significant sand accumulations, make up a large portion of the Coromandel Coast and play a crucial role in shaping the coastal morphology and influencing land use planning in the studied coastal zone. The entire coast of India is shaped by the natural movement of sand (littoral drift). In particular, the coastal stretch along Pondicherry shows a substantial net transport of sediment along the coast, which implies that the sand moves predominantly in one direction (Lakshmi et al., 2012). During 8–9 months of the year from March to October, the southwest monsoon moves sand northwards, while during the remaining winter months (3–4 months) sand is transported southwards by the northeast monsoon (Figure 4). The coastal region of Pondicherry and Tamil Nadu is one of the most vulnerable states to coastal hazards in India, particularly due to more frequent cyclones and storm surges in the face of climate change (Black et al., 2019). Sea-level rise due to climate change is another major challenge for the

low-lying coastal areas of the Coromandel. Due to increased climate variability, coastal areas are projected to experience higher tides and more intense storms arising from a warmer sea. These weather extremes generally occur during the monsoon season. During this period, sand is transported from the beach to the offshore sandbank, reducing wave energy. With the end of the northeast monsoon winds, the sand moves shoreward, driven by the waves. The natural movement of sand is therefore necessary to reduce the intensity of more frequent coastal hazards.

Providing a large number of functions—from sustaining fish habitats to providing space for boat parking—the traditional fishing techniques of the many fishing communities in the area evolved over centuries around a sandy beach ecosystem (Figure 2). In Tamil Nadu, some fishing communities have an unbroken tradition of over 2,000 years of occupying the space closest to the sea (Madhanagopal, 2023). In fact, the local ecosystem is associated with the particular fishing caste, the Hindu *Pattinavar* on the Coromandel Coast, who dominate this part of the coast. Traditionally, the *Pattinavar* have relied on strong self-governance through the evolution of institutions (e.g., *uur panchayats*), sometimes beyond state jurisdiction, to maintain social control and access to the use of fish resources and community management (Bavinck, 2001; Singh & Chellaperumal, 2014). Houses are built close to the coastline to ensure visibility of the sea to locate shoals of fish (e.g., changes in sea colour or wind direction). With the liberal and uncontrolled distribution of fishing equipment through private humanitarian aid after the tsunami in 2004, artisanal fishing has mainly switched to mechanised gear, although traditional craft is still used, especially close to the shore. In this, the lines between economic development and humanitarian aid were blurred and post-tsunami emergency reliefs by the government were tied to the inland relocation of artisanal fishing communities (Cohen, 2011; Wright et al., 2021). Being more labour-intensive, the artisanal fishing sector requires the largest number of fish workers who use coastal common areas, particularly sandy beaches, for the following purposes: boat landing and storage, boat repair and maintenance, catch drying, net mending and maintenance, and fish auction and sale. Coastal communities also need beach space for cultural purposes such as during the Maasimagam festival in which the local deities of nearby temples are carried to the sea for a ceremonial bath. Access to sand and the space for the seasonal formation of beaches is, therefore, critical to the livelihoods of sand-based fishing communities.

Figure 2. Artisanal fish workers along the Coromandel and Pondicherry in the 1950s. Source: PondyCAN (2008).

5.2. Historical Accounts of Shifting Sands and the Construction of Social Vulnerability

Along the Pondicherry coast, the first coastal structures to interfere with the natural movement of sand date back to the 1860s (Figure 3), when a 1.5km seawall was constructed to protect what is now known as the French Town, which was built over the sand dunes. From there, large granite boulders were continuously dumped along the beach road to strengthen the wall against erosion (Figure 3). However, it was a commercial harbour built by the Pondicherry government in 1986 at the mouth of the Ariankuppam River, about 1.5km south of the main town, which caused the most rapid erosion (Figure 4). Two massive breakwaters were built within the littoral zone of the coast to act as an artificial entrance. As a result, this artificial channel blocked the natural movement of sand and deposition of sediment, starving the coast to the north of the harbour and causing severe erosion due to the disrupted sediment budget. The construction of the harbour not only drastically exacerbated the erosion, but also set in motion a vicious cycle of coastal protection measures that resulted in the fortification of the coastline with seawalls and the trapping of sand resources by groins north of Pondicherry.

Figure 3. (a) Fortified Pondicherry (18th century); (b) Old Pier (1950s); (c) Seawall along beach road (1970s). Source: Lakshmi et al. (2012).

The construction of a 6km seawall between 2002 and 2003 further shifted the erosion from the Union Territory to Tamil Nadu. In the process, several km of beach and village land of fishing communities were lost to the sea. Guided by the narrative of taming nature, when the tsunami struck the coast in 2004, another push for hard infrastructure legitimised the enlargement of seawalls and the construction of groins to defend from and fight against the sea. Although other coastal areas outside the study site were more strongly affected by the tsunami due to different elevations, an abundance of funds was made available by the government for the implementation of new projects to protect the coast. A similar reactive dynamic unfolded in the aftermath of Cyclone Thane in 2011 (Punithavathi et al., 2012). Following this, proposals for groins by the Public Works Department on both sides (Tamil Nadu and Pondicherry) were passed without the environmental impact studies as demanded by NGOs or without obtaining Coastal Regulation Zone (CRZ) clearance. According to the CRZ Notification 2019, the area where groins were built falls under CRZ IV (water body) and CRZ IB (intertidal zone), wherein any construction is prohibited without CRZ clearing from the Coastal Zone Management Authority of Tamil Nadu (National Centre for Sustainable Coastal Management & Ministry of Environment, Forest and Climate Change Government of India, 2024). The CRZ include the coastal area up to 500m from the high tide line and falls under the governance of CRZ rules that demarcate coastal areas in different zones, for example, no development zones. As a result, the flow and distribution of sand resources have been drastically altered, with disputes between various coastal actors and devastating impacts on the artisanal fishing communities in northern Pondicherry.
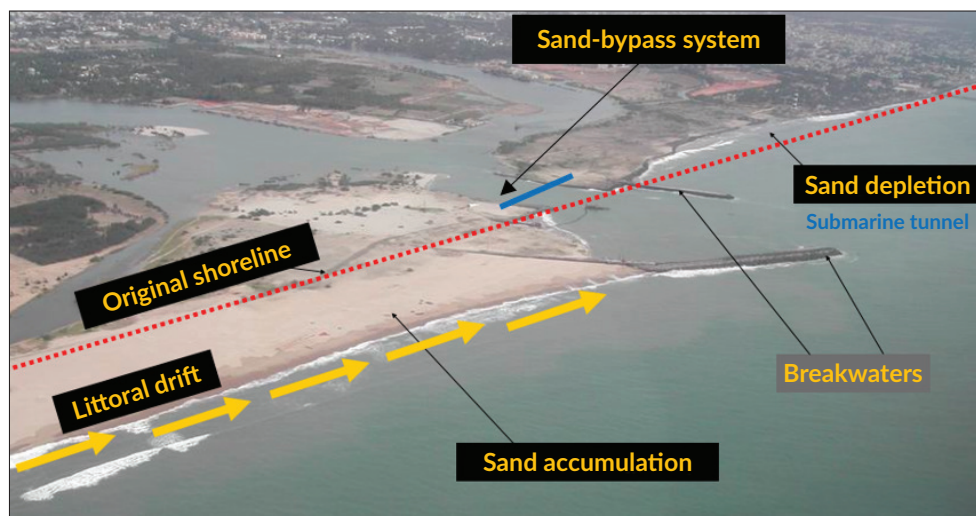
Figure 4. Aerial view of the Pondicherry harbour blocking sand at the mouth of Ayriankuppam River. Photo: PondyCAN.

To date, more than 80 hectares of the beach have been lost along the study area, affecting 20km of coastline, with more than 7,000 fishermen losing their livelihoods and at least a dozen fishing villages wiped out (Bautès et al., 2023). Artisanal fishers are still affected by the increasing loss of working space due to the loss of beaches. As beaches are lost and extended seawalls impede access to the sea many are forced to launch their boats from distant beaches outside their village or find new employment in urban areas. In addition, shoals of fish coming close to the shore have diminished, making artisanal fishers more vulnerable by pushing them further out to the sea where reportedly storms become more unpredictable as the Bay of Bengal is getting hotter. The disappearance of sandy beaches, which are closely linked to the livelihoods of fishing communities, has therefore contributed significantly to their social vulnerability. In response to man-made erosion, several fishing communities have made numerous attempts, including protests, road blockades, and hunger strikes, to reach out to their respective government to demand compensation, and protection of their villages and the beach in front of their homes.

5.3. Dammed Rivers of Sand and the Impact of Groin Fields

We follow ocean sand by unpacking the human–sand relations in the coastal development of a harbour, the construction of groins for coastal protection that led to the damming of sand rivers and the creation of a cycle of maladaptation. Although hidden and sometimes invisible in the sea, shifting ocean sand exerts agency over its use and is significantly involved in the social web that produces winners and losers in the making of coastal protection. It does so primarily by co-shaping the coastal morphology with humans who, for example, perceive and make sense of the loss of a beach in different ways. This notion of the "geosocial" is illustrated by the following quote from a respondent:

> Of building groins, you just see the land area, how much of beach we have lost. You can see that the beach has no value. Because it is public property or it is not private, so it has no value. (NGO interview, 2024)

Under the pressure to reclaim the lost sand resources, but without the approval of the environmental authorities, the Tamil Nadu government has constructed a series of about 12 groins reaching as far as Bommayiarpalayam, thereby diverting the erosion back into the Union Territory of Pondicherry (Figure 5). Groins are impermeable walls, usually made of rock, that extend vertically from land into the sea. Along the Coromandel Coast, groins are used to trap the sand as it moves northwards. While small beaches have formed along the structures, like the breakwater at the harbour (Figure 4), the groins have deprived adjacent shorelines of sand and rapidly accelerated northward erosion (Figure 5). A protesting fisherman states: "Don't allow Pillaichavady to make the groins, because if they make the structures, then we are gone" (Fisherman interview, 2023). The engineering of groins implicitly carries a logic of sacrificing the beach zones on which artisanal fishing depends. At the same time, the neighbouring fishing villages demand these measures as a last resort to preserve some of the lost ocean sand to protect their homes.

| 12/2020 | 09/2021 | 01/2022 | 08/2022 |
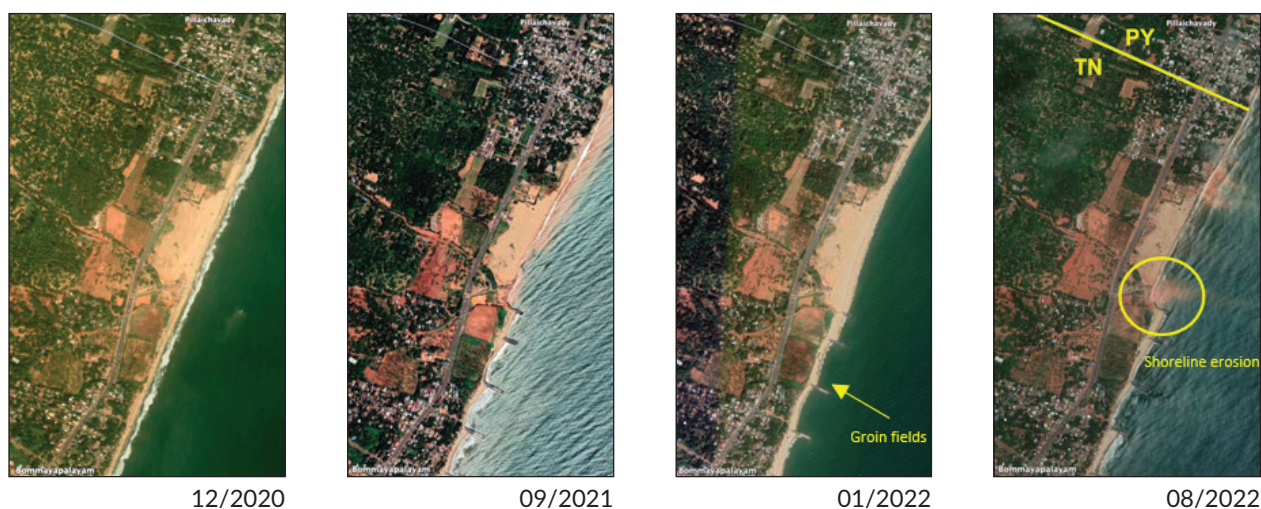
Figure 5. Time-lapse of satellite images documenting the construction of groin fields. Note: "TN" refers to Tamil Nadu and "PY" refers to Pondicherry. Source: Google Earth.

Artisanal fishers are forced to adapt to these spatial changes by moving where ocean sand newly accumulates on which they can safely store their gear. Faced with coastal pressure from all sides, the migration of fish workers often leads to conflicts with other self-governed fishing communities, mainly because of the interference in their livelihoods and the restrictions they face due to more boats that need to be parked on the sandy shore. Several interviews with affected fish workers highlight the constant mode of survival linked to their livelihood (e.g., seasonality and availability of fish or lucky catches), which leads to the urgency of quick solutions with short-term security. Reportedly claimed to be an emergency measure, the government builds hard infrastructure when it is too late, e.g., after a cyclone, and the "natural" disaster has already unfolded. A scientist at the National Centre for Coastal Research puts it this way:

> Suppose you have a stomach pain, what do you need? You need medicine to eat because you don't know. You don't have time to think about your pain, why it happens. What is the cause? So exactly the same. This groins and everything. I find it is a temporary measure without understanding the dynamics of the sea. (Coastal scientist interview, 2023)

In the long term, however, groins create dammed rivers of sand that, like a river dam, interrupt the flow of ocean sand and thus also redistribute who has access to ocean sand resources (Figure 6).

Figure 6. A groin in Bommayiarpalayam village is blocking sand movement northwards.

The starvation of ocean sand in Pondicherry was not unexpected when the harbour was constructed in 1986. After the decision in favour of groins, another human–sand entanglement needs to be unravelled, the dysfunctional sand bypass system and the failure to dredge the unevenly accumulated sand for beach nourishment: "What if I tell you, that you use that money not for dumping stones but for dredging? Because if they dredge, the sand will come and you don't have to put stones" (Civil society organization interview, 2023).

Instead, the design included a sand bypass system that allows the accumulated sand to be dredged and pumped to the other side, restoring the natural movement of sand and mitigating the effects of erosion (Figure 4). In the absence of regulatory monitoring and poor harbour revenue generation, lack of funding and political will led to the failure of maintenance dredging which would have been crucial for beach nourishment and de-silting of the harbour channel (interview, 2024). In the end, dredging was mainly carried out when the mouth of the harbour became clogged with sand to allow commercial fishing vessels, such as trawlers, to pass through. The allocation of ocean sand by the deepening of the channel here prioritises the trawler association of commercial fishers over the artisanal fish workers who depend on access to the sandy beaches of northern Pondicherry. The lack of access to the beach due to the disruption of seasonal sand movement forces fish workers to relocate their gear to newly formed beaches where boats can be parked safely (Figure 7). These dynamics show the underlying vested interests and unequal power relations over the distribution of sand resources, also given that fish workers from Tamil Nadu are not allowed to use the Pondicherry harbour and its construction which was done without prior consultancy of the affected fishing communities.

Figure 7. Fish workers relocate their gear to a coastal space with wider beaches.

However, a critical question remains regarding the adaptation to coastal erosion by artificially creating sandy beaches: "If they can spend so much money in building groins, why can you not spend money and just reactivate this sand bypass system and your problem is solved?" (NGO interview, 2023).

To a large extent, such decisions by government authorities can be answered by understanding the vicious cycle of hard measures that have been created, underpinned by strong modernist narratives of flood control and defence *against* the sea rather than *with* the sand. Grains of sand in the coastal environment are like "free spirits" that never stand still (interview, 2023). However, as in many other Indian coastal cities, and at a cost of several crores of rupees, the Public Works Department has facilitated large-scale operations to dump massive rocks, extracted and trucked in from quarries in the Tamil Nadu hinterland, to stop the movement of sand and fortify the coast, as it was conducted by the French in colonial times (Lakshmi et al., 2012): "Whenever we face the sand problem, we will engage some cranes and Hitachi machines to pick up the stones buried into the sea that is development work" (Coastal authority interview, 2024). The continuous movement of ocean sand causes the rocks to sink further and further, requiring new hard materials to maintain the hard coastal defences. Consequentially, continuous northward erosion has created a "sustainable business model" (interview, 2023) in the sense that there is a never-ending demand for more rock to adapt to the disrupted sand flows created (Figure 8).

While climate change is not discussed as a cause of erosion at the local level, projects proceeding under the outlined status quo of coastal protection are increasingly framed as climate change adaptation. The National Bank for Agriculture and Rural Development, for example, has been accredited to the Green Climate Fund and by the Adaptation Fund Board of the United Nations Framework Convention on Climate Change to implement climate change adaptation and mitigation programmes, particularly through the Rural Infrastructure Development Fund. With a focus on technocratic measures, the construction of groins falls under the category of rural infrastructure projects for flood protection and projects benefit from new
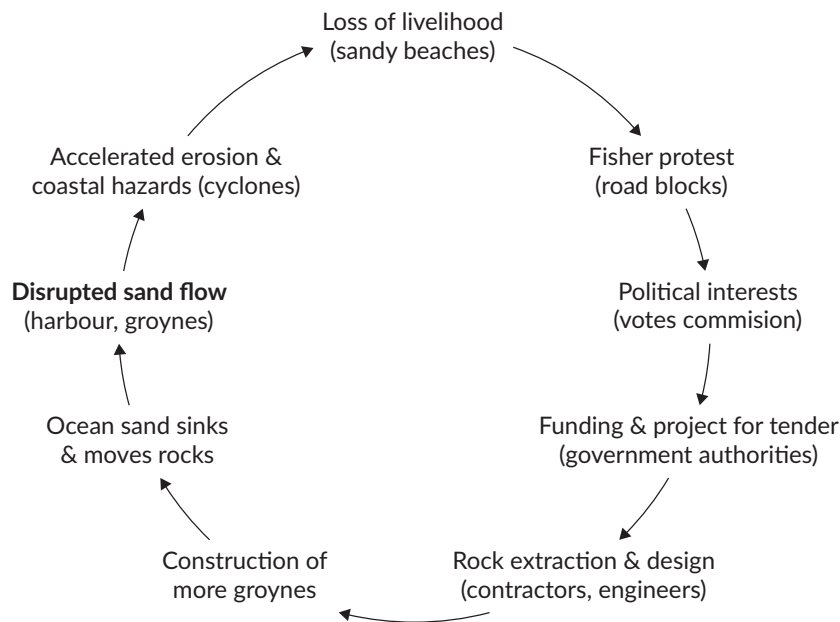
Figure 8. Cycle of coastal maladaptation.

sources of funding. An interviewee from a local NGO complains, "Because of this whole emphasis on climate change it almost kind of makes you helpless on the local level" and "today every funding comes only with a climate change tag." This re-labelling overlooks the materiality of sand and thus sidelines an investigation of the root causes of sand loss (Connell, 2003). Moreover, coastal interventions in the sandy intertidal marine zone play into the pockets of political parties that have seized the opportunity to create new coastal protection or adaptation projects:

> It is a continuous money-making thing, because on the one hand these stones will sink, and you have to keep more stones and secondly you have to keep extending. Politicians are happy to produce this kind of projects. These are big-budget projects. So, the moment Pillaichavady makes groins they will need a contractor to start mining the stones, procuring the stones. There are so many levels. At every level, money has to be given. If you don't give money, you don't get your groins. (Interview, 2023)

The failure of soft adaptation measures, such as dredging for beach nourishment, is linked to the vested interests of various actors ranging from coastal engineers and quarry owners to the transporters and contractors who are paid to transfer rock, not sand, from one ecosystem to another. Repeatedly, the implementation of such infrastructure suffers from poor planning, with little of the planned budget left over after the funds have been allocated and the projects commissioned. Corruption also often delays the implementation of protective measures, increasing vulnerability during the monsoon season. In this way, local politicians who need votes to stay in power respond to the demands of the protesting fish workers without having enough time to consider more holistic approaches to long-term coastal management. For example, the engineering of interventions that trap sand faces the increasing unpredictability of how much sand will actually move. As more and more structures are built along the coast, it becomes almost impossible to calculate back the "natural" transport of sand and therefore to model the potential effects of shifting erosion. In addition, the relocation of large quantities of ocean sand for beach nourishment makes monitoring even more difficult:

> What happens when the dredger comes? The meter will tell you how much sand is going out. The first thing they will do is break the meter because if the meter is not there, you make five hundred metre cubes and you sell them for five thousand. How do you check? (Coastal authority interview, 2024)

Inherent in the materiality of ocean sand future adaptation projects and past coastal protection are bound up with the difficulties of monitoring sand loss, predicting sand movement and, ultimately, allocating a fair share of sand to the communities that depend on it. The materiality of ocean sand, in particular, its unruliness across political boundaries and its agency in social processes, such as adaptation, raises complex issues for coastal governance and the appropriateness of the demarcations it proposes in different coastal zones. Geosocialities scholarship thus opens up new avenues for interdisciplinary research to deepen our understanding of forms of geomorphological agency, here ocean sand, and society. While this article has attempted to do so by exploring the coastal dynamics around artisanal fishers and coastal protection strategies, this approach is limited to capturing the broader global environmental governance architecture related to climate change adaptation. Thus, one of the major challenges is not only to extend the time scale of ocean sand observations but also to trace the global in the local by extending the spatial scale of the analysis. This will require future work that goes beyond the material implications and considers, for example, the broader politics of knowledge production that guides and legitimises future adaptation strategies.

6. Conclusion

This article reveals the complex (non)human relations between ocean sand, artisanal fishers, and the making of coastal protection at multiple spatial and temporal scales. Tracing human–sand entanglements along the Coromandel renders visible the governance challenges inherent in dynamic coastal environments. Through its movement and accumulation, ocean sand has the power not only to adapt to hard infrastructure but also to interact with the actors who depend on it (Kothari & Arnall, 2020). Adaptation outcomes depend not only on the material conditions of how ocean sand shapes the coastal environment but also on how different actors negotiate its (re)distribution. From a livelihoods perspective, zooming in on ocean sand highlights the pitfalls of property rights that focus solely on land-based livelihoods and overlook shared beach spaces. Future adaptation measures must therefore treat mobile ocean sand as a secured public good that actively forms the basis of coastal environments and the fisheries that depend on them. Following the locations of disrupted sand flows permitted the unpacking of human–sand relations and brought to the fore a situation of sediment starvation caused by a harbour or the attempt to dredge and pump sand for its accumulation to mitigate coastal erosion. In this case, the narrative of protection from a violent sea guided the implementation of groins, resulting in the disruption of sand flows and the loss of livelihoods for thousands of artisanal fishers. Similarly, as Anand et al. (2018, p. 2) point to infrastructure as a "terrain of power and contestation," the implementation of coastal infrastructure in particular, such as groins, is embedded in unequal power relations. This raises questions of environmental justice in future adaptation efforts: To whom will ocean sand resources be distributed and from whom will they be taken?

To address this question, we conclude that recognising ocean sand as a non-human agent offers new perspectives for addressing coastal erosion and sea-level rise in the context of coastal adaptation strategies. Acknowledging the agency of non-humans helps overcome the long-established Western notion of modernity underpinned by dominating nature through technology and hard coastal infrastructures (Arnall, 2023). We show how adapting to coastal hazards through static measures that ignore the dynamics of ocean

sand deepens the vulnerabilities and inequalities of some populations more than of others. Engaging with the fluid materiality of ocean sand therefore provides a lens through which to analyse the hidden complexities of different coastal actors in managing coastal risk. Our empirical study also relates the construction of a destructive harbour to the cycle of constant hard solutions to prevent further erosion to the north. It thus opens up new relevant avenues for a case of undoing the coast in future adaptation-making with the aim of preventing the disruption of sand flow and reducing the risk of maladaptation. The concept of "geosociality" here helps to imagine new forms of agency to reshape the entangled geographies of static coastal development policies. It forces policymakers to be aware of the trade-offs between prioritising development and economic growth (e.g., harbour) over transformative coastal adaptation strategies. Uncertainties in adaptation planning and the making of coastal protection design are hereby linked to the materiality of ocean sand and therefore need to be investigated as such when understanding the local vulnerability contexts in which climate change adaptation projects materialise.

Because of the shifting boundaries of the shoreline, which are neither water nor land, coastal adaptation processes are accompanied by a less clear legal framework than on land. In addition, these processes must take into account different competing actors and their interests in the use of coastal resources (Alexander, 2021; Bavinck et al., 2017). In the case of Pondicherry and Tamil Nadu in particular, adaptation to ocean sand flows also requires recognising them as a vital political entity that operates across politically determined state boundaries, but within large sedimentary cells. Ignoring this has transferred and exacerbated coastal erosion to neighbouring jurisdictions where self-governed fishing communities compete for shrinking beach space. The complexity of coastal adaptation stems not only from the uncertainties of climate change impacts but also from vested interests in the use of diminishing sand resources and the unruly character of continuously moving ocean sand (Hein & Thomsen, 2023). Ultimately, ocean sand in its various functions and uses is at the very centre of coastal adaptation processes and coastal risk management policies. Our case links to other work showing how livelihoods dependent on sand resources are forced to adapt to changes in sand availability (Lamb & Fung, 2021). The ability to access, use, and relocate sand resources determines winners and losers in these processes. We conclude by borrowing from the phrase: Not to bury our heads in the (ocean) sand by ignoring the very foundations of the land–sea interface!

Conflict of Interests

The authors declare no conflict of interests.

Supplementary Material

Supplementary material for this article is available online in the format provided by the author (unedited).

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ARTICLE

Navigating Coastal Dynamics: Illegal Institutional Arrangements, Gangs' Activities, and Knowledge Mobility in the Gulf of Guayaquil

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Abstract

This study investigates how corruption and criminal gangs affect small-scale fisheries, driving forced displacement and reshaping fishing knowledge through the process of epistemic mobility. The research focuses on the interactions between the fishing communities of Puerto Bolívar and Puerto Roma within the Gulf of Guayaquil, Ecuador. By tracing the movement of fishers and their knowledge, the study reveals how the imitation and attempted learning of fishing techniques, such as the use of plastic tubes to detect fish, occur between communities. Displaced due to the illegal encroachment of semi-industrial vessels (*bolicheros*) protected by criminal gangs, Puerto Bolívar's fishers have been forced to migrate northward to fish near Puerto Roma, and then return to Puerto Bolívar. While they are fishing in the northern waters, Puerto Roma's fishers observe their techniques and attempt to imitate them. Nonetheless, the transfer of this knowledge is imitative and incomplete, as it is observed from a distance rather than fully understood. The study highlights that, while the displacement caused by corruption and illegal activities brings fishers into new contexts, it is the fishers themselves who contribute to the mobility and transformation of knowledge. By focusing on epistemic mobility, this study highlights how knowledge is not always successfully transferred but is adapted, hybridized, or even resisted, offering new insights into the resilience and vulnerability of small-scale fishers in the context of systemic corruption and ecological conflict.

Keywords

conflicts in fisheries; criminal gangs; epistemic mobility; fishing industry; illegal institutional arrangements; knowledge; small-scale fisheries

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1. Introduction

When asked who advocates for their needs, artisanal fishers responded simply: "No one. We do it ourselves" (fisherman, personal communication, May 31, 2023). This answer illustrates the daily life of communities in the Gulf of Guayaquil, a critical ecological and economic zone now facing immense challenges due to the interplay of the entry of the fishing industry into the artisanal fishery zone, corruption, and the socio-economic dynamics of small-scale fishing communities. Illegal fishing vessels, known as *bolicheros*, increasingly encroach on areas designated for artisanal fishing, creating resource depletion that forces local fishers from Puerto Bolívar (downstream) to temporarily move to fish grounds in Puerto Roma (upstream) as the stocks in their own areas diminish. The corruption within institutional frameworks further complicates these dynamics, as bribery enables industrial operations to exploit these areas with little oversight. This situation not only threatens the livelihoods of small-scale fishers but also fosters conflicts among them as competition for dwindling resources escalates. In this context, this study explores how these factors impact local fishers and how the movement of knowledge (termed epistemic mobility) plays a crucial role in shaping fishing practices and community resilience. This study investigates how knowledge is shared, transformed, and sometimes contested within the context of displacement and environmental change.

This article is structured as follows: Section 2 outlines the conceptual framework, including theories on institutional arrangements, corruption, and epistemic mobility. Section 3 presents the background of the fishing communities in Puerto Bolívar and Puerto Roma, detailing their historical and ecological contexts. The methodology employed to gather data is described in Section 4, followed by the results in Section 5, illuminating the current dynamics of fishing practices and conflicts. Finally, the discussion and conclusions in Section 6 synthesize the findings, linking them back to the theoretical framework while advancing our understanding of the complex relationships between knowledge, mobility, and fisheries management in the face of industrial pressures.

2. Conceptual Framework

We define institutions as "an aspect of culture, a set of habits, rules or values" (Jentoft, 2004, p. 138). Institutions are frameworks that shape social interactions through norms and rules. As institutional arrangements, we refer to the formal and informal rules or practices that "guide and constrain behavior" (Olivier & Schlager, 2022, p. 341), "provide opportunities" (p. 347), and "condition and shape interactions" (p. 343) within an organization or between organizations. Institutional arrangements are influenced by history and culture and can breed prosperous as well as perverse practices, which can in turn breed the prevalence of illicit rent-seeking or corruption and undermine the performance and legitimacy of institutions (Nunan et al., 2018).

The occurrence of corruption, "through the payment of briberies to avoid sanctions and to enable illegal practices to continue" (Nunan et al., 2018, p. 60), is a factor that indicates weak enforcement and non-compliance (Gezelius & Hauck, 2011; Sundström, 2013, 2016). In general, in the case of fisheries, the navy is the patrol institution in charge of governmental surveillance of the interior waters, which includes controlling and stopping the fishing industry from entering such waters, whether by means of industrial or semi-industrial vessels. Active bribery is defined as "the promise, offering or giving to a national public official...of an undue advantage, in order to act or refrain from acting in matters relevant to official duties"

(United Nations Office on Drugs and Crime, 2019, p. 3). Bribery by the fishing industry to the navy enables illegal fishing—defined as a "violation of applicable international, regional, or national fisheries regulations" (Petrossian, 2019, p. 23)—and indiscriminate fishing in areas reserved for small-scale fisheries, leading to resource depletion, heightened conflicts (Spijkers et al., 2021), and the displacement of artisanal fishers in search of new waters.

While historically fishers have been mobile, following the seasonal availability of fish (Lund, 2020), in the Gulf of Guayaquil recent shifts in mobility are more closely tied to illegal institutional arrangements. In our case study, criminal gangs have played a key role in these dynamics by protecting semi-industrial boats connected to the fishing industry since 2016. This illicit collaboration allows *bolicheros*—semi-industrial trawlers with advanced radar systems capable of locating large shoals of fish (Ertör & Ertör-Akyazi, 2023)—to encroach on artisanal fishery zones. These zones, intended for traditional fishing, are increasingly co-opted by industrial operations under illegal agreements between the navy and industrial players. The resulting overexploitation renders these spaces unsustainable for artisanal fishers, driving their forced displacement and exacerbating resource conflicts.

This conflict between the fishing industry and small-scale fisheries in artisanal fishery zones creates consequences that impact not only the communities directly affected but also other communities due to the displacement of artisanal fishermen searching for fishing grounds. In summary, the presence of *bolicheros* leads to increased pressure on upstream fishing grounds, illustrating the spatial interdependence of communities and ecosystems within the Gulf of Guayaquil. Spatial interdependence refers to the concept that geographic phenomena are interconnected, meaning that the characteristics or behaviors of one spatial unit can influence those of another. This principle is often encapsulated in Tobler's first law of geography, which posits that "everything is related to everything else, but near things are more related than distant things" (Schimohr et al., 2022). This foundational idea highlights the importance of proximity in understanding spatial relationships and interactions, and at the same time underscores how local decisions and movements can have broader impacts, despite seeming like isolated events. This concept echoes Partelow's (2023) emphasis on the interconnectedness of marine spaces and the need for governance frameworks that account for these spatial dynamics.

To develop our argument about fishers' displacement we use the "mobilities paradigm" (Sheller, 2018; Sheller & Urry, 2006) and the notion that different forms of mobilities "of people, materials, ideas, technologies, knowledge and risks are already producing and reproducing social relations" (Boas et al., 2022, p. 3368) at the local, regional, and global scales (Boas et al., 2022; Wiegel et al., 2019). Displacements of fishers are embedded in socio-economic, cultural, political, and environmental contexts (Hapke, 2001; Lund, 2020; Weeratunge et al., 2010). Considering illegal institutional arrangements as one of these factors, we will unveil how the movement of fishermen from an affected area to a destination area is carried out, how it evolves, and what it brings to the picture when other communities receive the displaced fishers. The location of this case study in the Estuary of the Gulf of Guayaquil allows us to explore both the downstream areas near the Pacific Ocean as well as the upstream regions within the Central Interior Estuary, weaving a narrative that, while context-specific, can offer insights into local mobilities in other coastal areas around the world.

The movement of fishers is accompanied by the movement of their knowledge, a phenomenon known as epistemic mobility, which is central to this research. The fishers from Puerto Bolívar have adapted their

knowledge of fishing over time, incorporating innovative techniques such as the use of a plastic tube to listen for fish. Ruddle (1994, p. 163) describes this integration of modern materials and methods into their fishing repertoire as "hybridized knowledge," a mix of traditional practices and adaptations influenced by outside factors. As these displaced fishers displace fishing operations upstream to the point of Puerto Roma and further, they bring this evolved knowledge with them, and some local fishers begin to adopt these practices. This exchange illustrates the process of epistemic mobility, where embodied knowledge is transferred from one community to another (Hornidge et al., 2020).

Upon migrating upstream, Puerto Bolívar's fishers are faced with a new ecological context to which they must once again adapt. Their ability to adjust is not just a reflection of their practical knowledge, but also of their capacity to experiment and innovate. As Hornidge et al. (2020, p. 1498) point out, these fishing techniques "embody knowledge, genius, and practices of experimentation that are semistable and transferable to a certain extent." This knowledge, once displaced, becomes part of a process of translation and transformation, evolving as it interacts with a different ecological and social setting.

When downstream fishers bring their local open-sea knowledge to the upstream community, two distinct responses emerge in the latter: while some fishers adopt and imitate these new techniques, others continue to rely on the ancestral methods traditionally used in the mangrove estuary. This ancestral knowledge passed down through generations, belongs to the community and reflects a way of life intimately connected to the coast and its resources (Molina Camacho et al., 2018). The difference in approaches highlights a divergence in fishing practices, where one group embraces the incoming knowledge and another—the one we refer to as the "mangrove-ancestral" group—remains loyal to their longstanding methods, which have undergone fewer changes. This stability in their practices is partly because the upstream fishers have not experienced displacement, allowing them to preserve their techniques. Drawing on Scott's (1989) concept of everyday forms of resistance, these fishers quietly maintain their ancestral practices, avoiding attention, remaining unorganized, and eschewing open confrontation, yet continuing to pass down their knowledge to future generations.

3. Background: Downstream and Upstream Case Studies

In the coastal province of El Oro, where Puerto Bolívar belongs, there are 11,000 artisanal fishers and 67 fishers' associations (Fernández-Espinosa et al., 2021). Puerto Bolívar is located in the downstream area of the Interior Central Estuary of the Gulf of Guayaquil. This southern area is the closest area to the Pacific Ocean (Ecologically or Biologically Significant Areas, 2017). It is a port with a history of mangrove resource gathering and fishing practices ("La pesca es," 2014; Fernández-Espinosa et al., 2021), that has spread local knowledge to other communities. For example, during fieldwork, fishermen from other southern coastal communities said that some techniques, such as fishing with the help of a plastic tube, were practices learned from the fishers of Puerto Bolívar. Puerto Bolívar's fishers say that, over time, different techniques have been used. For example, 25–30 years ago, they would place their heads on the floor of the boat to listen for the sounds of the fish. Another technique involved sticking the boat's wooden paddle into the water and placing their ear on top of it to hear the fish (Figure 1). These methods evolved over time and, by 2015, they began using a plastic tube with lids on both ends, which they submerged into the water to listen for fish. They can identify different species by their sounds—according to them, for instance, the sea bass makes a croaking noise.

Figure 1. Adaptation of fishing techniques by Puerto Bolívar fishers to detect fish through sound. Notes: The first two techniques shown in Figure 1 were used almost three decades ago, while the use of the plastic tube started in 2015; The illustrations were created by Subash Surendran Padmaja, an Indian researcher, for this article.

Puerto Bolívar is in the proximity of the Jambelí Archipelago (the downstream part of the Gulf of Guayaquil) and therefore has a close relation with those communities. When asked why some fishers of the communities of the Archipelago know how to use the tube, the president of one Puerto Bolívar association said that some of them are relatives or friends who have come to Puerto Bolívar to take part in the fishing work, which has allowed the teaching and the learning of the technique. Currently, the use of this technique is common among the communities in the Jambelí Archipelago.

Regarding fishing methods, Puerto Bolívar's fishers used to fish with large-mesh green textile nets, but these have also evolved. Currently, they use what is known as the electronic fishing net, which has a smaller mesh and is made of transparent nylon. They explained that the older green net becomes heavier when wet, which is why they stopped using it. The nylon nets are more convenient and easier to handle. Since they fish in the area of the Gulf facing the Pacific Ocean, which is vast, they cast the nets and wait for a while until the fish become entangled in them.

Navigating upstream in the Gulf we find Puerto Roma, a community located in the north of the Interior Central Estuary of the Gulf of Guayaquil, surrounded by thick mangrove forest. The fishers here recognize themselves proudly as ancestral crab gatherers of that area of the Gulf, compared to other nearby communities that used to dedicate themselves mostly to mangrove cutting or fishing (fisherman, personal communication, March 15, 2024). They have an association and a cooperative of crab gatherers and fishermen with 338 members, out of whom only 17 are dedicated exclusively to fishing using different techniques. There are approximately 43 fishermen in the community, though the others are not members of the Fishermen's Association or the Crabbers' Cooperative. We highlight that, during the closed season of the red crabs, some crabbers dedicate themselves to fish as their alternative source of income.

In contrast to the Jambelí Archipelago and the open-sea type of fishing, the communities of the Interior Estuary have been accustomed to a "mangrove type of fishing," which is characterized by fishing in narrow estuaries. Also, this type of fishing retains the characteristics of the past (Koelle, in press), and their techniques have experienced a very low level of change, compared to the Puerto Bolívar fisheries. For example, they still use the large-mesh green textile nets, and they fish in a very slow way, throwing the fishing nets into the water and waiting for a while to retrieve them, because that is how they learned to do it.

4. Methodology

For this research, the first author carried out nine months of intensive fieldwork between October 2022 and June 2023 in different places in the Gulf of Guayaquil to develop an understanding of the general living conditions and the dynamics between coastal communities. Specific for this research was the two-month ethnography carried out in Puerto Roma as well as two visits to Puerto Bolívar. To understand the dynamics of the entrance of the downstream fishers in the upstream area we held five focus groups. In Puerto Roma, we conducted two focus groups (nine participants), each consisting of daily fishers who use distinct fishing practices. In Puerto Bolívar, we held two focus groups with the Pesquerita Fishermen's Association (seven participants) on separate occasions. One focus group was conducted in another downstream community to discuss the relationship between semi-industrial vessels and criminal gangs. For security reasons, we anonymized the names of the downstream communities and the Puerto Bolívar association since the locality has a high crime rate due to the presence of criminal gangs. Interviews and focus groups were conducted with informed consent, which was approved by the Center for Development Research of the University of Bonn. The recordings of this material are stored in a digital cloud under the first author's custody. Part of the inputs was an informal interview with the president of an association in Puerto Bolívar to validate information in 2024, from which notes were taken, and the names of the person and organization anonymized.

At the public-sector level, we interviewed the director of policy of the Vice-Ministry of Fisheries of Ecuador along with two officials from the National Institute of Fisheries, and we held one off-the-record interview with a high-level official from the Ecuadorian navy (Puerto Jambelí Department).

In addition, we analyzed 14 articles from national and local media newspapers (Table 1) over the period 2007–2024, that covered news about conflicts related to the presence of semi-industrial vessels in Puerto Bolívar waters, the gang situation, and the entrance of small-scale fishermen of Puerto Bolívar into Puerto Roma (only two articles in grey literature had covered the latter).

Printed maps of the Gulf were used in the focus groups and interviews to locate the entrances of the vessels and to understand the path of the displacement. Fishing trips were recorded in the PocketTravel app. After that, we used the programs QGIS and Canva Pro to generate and illustrate our narrative.

5. Results

5.1. Illegal Institutional Arrangements Cause Displacements Between Downstream and Upstream Areas

Puerto Bolívar's coast experiences a constant entrance of semi-industrial ships called *bolicheros*, which belong to the fishing industry and are smaller than industrial vessels; therefore, they can more easily enter artisanal fishing waters and anchor offshore. The *bolicheros* are trawler vessels using trawls or nets to catch fish. They catch 20 to 40 times more than artisanal fishers (López, 2020, p. 168). In Puerto Bolívar, different species of fish can be captured, but the most important, due to its high price on the market, is the sea bass, or as locals call it, "the croaker."

Based on interviews between February and March of 2023, there were 23 *bolicheros* anchored near the coast, fishing in the water for several days. Fishermen from the Pesquerita Association indicated that these ships belong to the Ecuadorian industry. While some come from northern provinces, others come from the northeast (Posorja), and yet others are from Puerto Bolívar (Figure 4). In total, these semi-industrial vessels fish in the Puerto Bolívar area, violating Article 104 of the Law of Aquaculture and Fisheries of Ecuador, which indicates that "the zone established for artisanal fishing shall be declared as the area within eight nautical miles, where the recruitment processes of bio-aquatic species are carried out" (Asamblea Nacional del Ecuador, 2020, Article 104).

The entrance of semi-industrial vessels has led to a decrease in the fishing stock of Puerto Bolívar. For this reason, small-scale fishers have "followed the seabass fish shoal" and, in this quest, have moved upstream in the Gulf. Currently, they travel to places such as Puná and Puerto Roma (Figure 4). As recorded, "before we had no need to go to Puná" (Participant 1, focus group), meaning that they did not need to move upstream in the Gulf looking for the fish, as they do nowadays.

The navy's role is ambiguous since some media reports indicate that certain vessels have been held back (OANNES, 2011), but others indicate that small-scale fishers complain about the authorities' inaction ("Naves grandes van," 2010). Social media and newspaper material have covered both the successes and failures of the Navy in capturing *bolicheros* (Table 1). Interviews with fishermen from Puerto Bolívar implied that the navy was not safeguarding the coast from criminal gangs (called "pirates") but was receiving bribes from the industry. Fishers in Puerto Bolívar claimed that "the navy goes closer to the *bolicheros* when they have put the nets in the water, they [the officials] get in the boats, to the wheelhouse, and then they leave, and the *bolicheros* stay there fishing" (Participant 2, focus group). Additionally, fishers reported that the navy asked them to indicate on a map where the *bolicheros* fish, but they answered that they had done this before and that the navy already had this information, yet there was no resolution to the problem. This goes in hand with other complaints such as the navy's lack of budget to patrol the ocean, which is an answer fishers receive when requesting surveillance in the artisanal fishery waters.

Regarding the encroachment on the part of the *bolicheros*, we also consulted the vice-ministry of Fisheries. A representative indicated:

> We can only track through the satellite tracking devices that are installed by law on industrial vessels, and we can see where they are, how many they are, in which areas they are, and we can control the issue of the eight miles [the artisanal zone].

However, fishers from different localities state that this tracking is not always effective. For example: "There have been some sanctions, but what is the industrial ships' strategy? They turn off the detector, and if the Ministry comes, they say it has been damaged" (fisherman, personal communication, March 3, 2023). In Puerto Bolívar, fishers said, "This is a lie that they do not even believe themselves" (Participant 3, focus group), meaning that control is not effectively executed. The president of another Puerto Bolívar Association indicated that another strategy used is to remove the radar from the *bolichero* and place it on another vessel that will remain outside the eight miles so, while the *bolicheros* enter the interior waters, their radar appears to comply with the law (fisherman, personal communication, September 9, 2024).

Table 1. Local news coverage of escalating conflicts: Displacement of artisanal fishers, illegal intrusions of *bolicheros*, and criminal gangs operations.

No.	Date	Title of the news	Local newspaper or website
1	July 20, 2020	"Fishermen Complain About Croaker Exploitation"	*El Universo*
2	August 17, 2010	"Big Vessels Go to the Artisanal Fishery Area"	*El Comercio*
3	October 27, 2011	"In Puerto Bolivar Industrial Vessels Continue to Disrespect the 8 miles"	*OANNES & La Hora*
4	December 30, 2012	"Artisanal Fishers Report the Invasion of Vessels"	*El Telégrafo*
5	May 29, 2014	"Operation 'Marea Alta' Dismantled Dangerous Pirate Gang Operating Along the Coast of El Oro"	*Ministry of Government of Ecuador*
6	August 14, 2018	"11 Arrested in Puerto Bolivar Riots"	*El Telégrafo*
7	August 26, 2019	"Fishermen Say They are Threatened if They Report: Four Criminal Gangs Cause Terror in Fishing Sector"	*Diario Correo*
8	November 26, 2020	"Why Ecuador is Victim and Accomplice of Illegal Fisheries?"	*Magazine Fisheries and the Environment*
9	February 15, 2020	"Gangs at War"	*Diario Correo*
10	February 22, 2020	"Crimes at Sea are Shipwrecked in Impunity"	*Plan V*
11	May 2, 2022	"Artisanal Fishermen in Ecuador Struggle Against the Tide"	*Revista La Brava*
12	December 28, 2023	"T-shirts on Engines, Extortion to Fishermen"	*Bitácora Ambiental*
13	May 28, 2024	"Terror Rules in Puerto Bolivar: People Live Silenced by Violence"	*Diario Extra*
14	May 28, 2024	"Puerto Bolivar: War Between Fractions of Los Lobos Keeps the Population in Anxiety"	*Primicias*

Another illegal institutional arrangement that has caused Puerto Bolívar fishers' displacement to the north is that claiming their rights to artisanal fisheries is not an option when the *bolicheros* are protected by criminal gangs. Any action against the *bolicheros* can result in the death of small-scale or artisanal fishers of Puerto Bolívar. So far, grey literature has reported on the problem of piracy through a narrative that sees the semi-industrial vessels and the small-scale fishermen as victims of piracy. Though this has been happening for a long time, our informants indicated that a critical juncture in the dynamics of the Gulf started around 2015–2016 when tired of being attacked by the pirates or criminal gangs, some of the semi-industrial *bolicheros* vessels that belonged to the industry, took the initiative of entering into a pact with them requesting their protection. The way they operate now is fishing illegally while being safeguarded by the pirates (Figure 2).

This informal arrangement between the industry and the gangs has made the communities even more vulnerable because they are afraid to complain about the invasion of the *bolicheros*. This research is the first academic source that documents this arrangement. Extracts from a focus group are:

> They formed an alliance, we are talking about...2015 or 2016....The *bolicheros* were also afraid because they were being robbed too, so they found a better strategy, which was to pay them [the pirates and the gangs]...with fish, to protect them. The thing is it is not just one gang. There are several gangs.

Figure 2. *Semi*-industrial trawlers guarded by criminal gangs. Note: The illustrations were created by Juan Carlos Gilbert, an Ecuadorian artist, for this article.

> Moreover, if one thief comes, then another thief comes. So [they thought]: it is better to have this guy [a pirate] protect me. (Participant 4, focus group)

The complexity is highlighted by the fact that pirates also live in Puerto Bolívar. Fishers have normalized living in these conditions, saying they do not complain or report because "at any time we can be taken" (Participant 5, focus group). Pirates are also related to narcotrafficking gangs, which have started charging an extortion fee called *la vacuna* (the vaccine) to fishers: "Not to be stolen [from] we pay the vaccine, which is $100 monthly" (Participant 6, focus group).

Our map in Figure 3 weaves the narrative of coastal dynamics in the Gulf: Extraction through semi-industrial vessels operating within the artisanal fishery zone from (1) Posorja and (2) Puerto Bolívar, with protection from criminal gangs, forces small-scale fishers from (3) Puerto Bolívar to move following the fish shoal to (4) Puná and (5) Puerto Roma. Though they are forced to move, these fishers disseminate their knowledge in upstream communities before returning home to Puerto Bolívar after each journey.
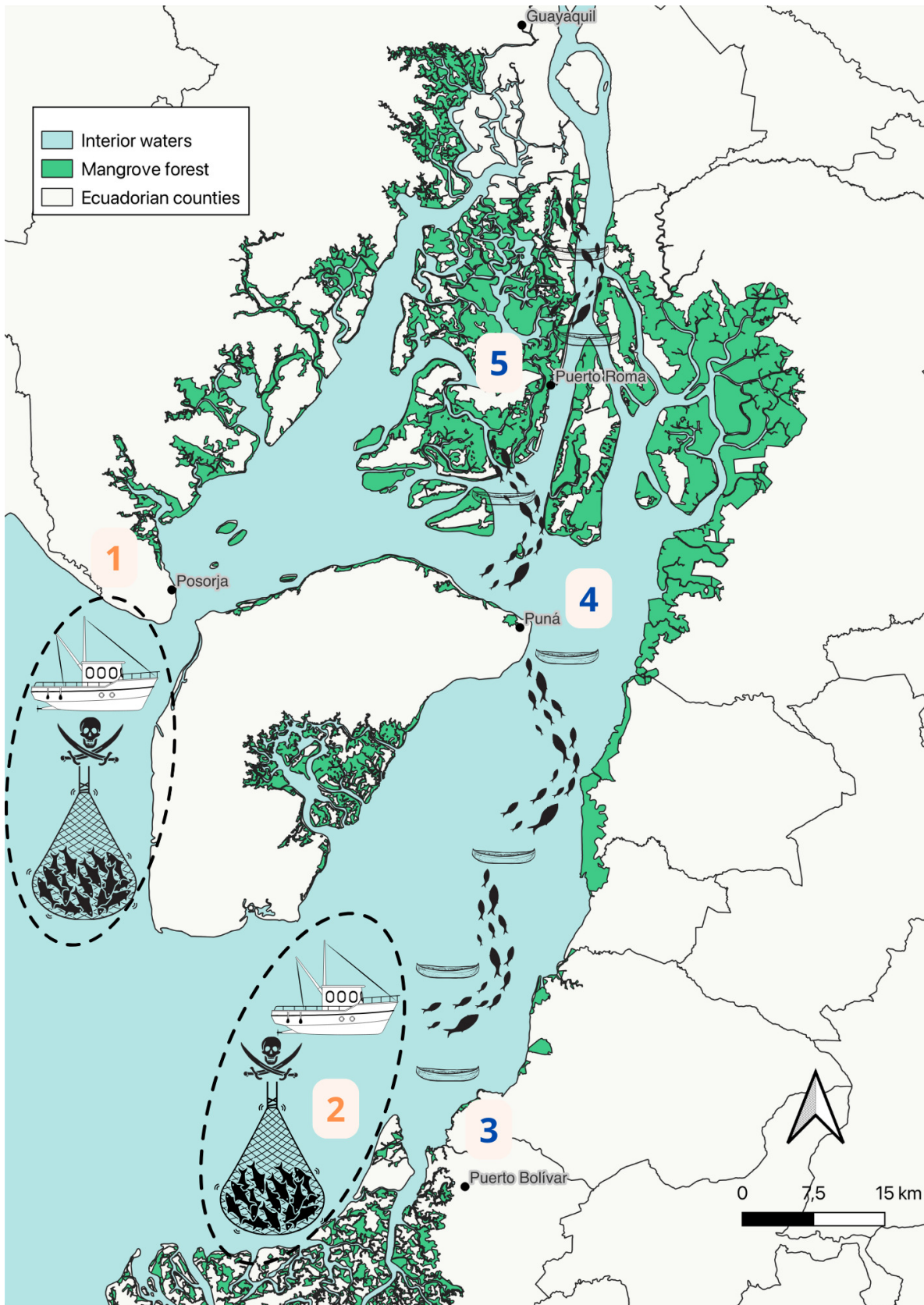
Figure 3. Illegal institutional arrangements force the displacement of downstream fishers to upstream waters.

5.2. Epistemic Mobility Woven Through Displacement

Affected by the illegal entry of *bolicheros*, fishers from Puerto Bolívar have moved across the Gulf of Guayaquil, spreading their local knowledge to other towns. When fishermen from Puerto Bolívar navigated upstream to the waters around Puerto Roma, the local fishers were unaware of the abundance of sea bass in their area, nor did they know how to fish as effectively as the people of Puerto Bolívar. The latter had mastered their techniques, and now use the plastic tube casting their nets once the sound of the sea bass is detected. The fishermen of Puerto Roma observed the arrival of these newcomers with curiosity and, seeing the large quantities of sea bass they caught, sometimes asked for fish, which the Puerto Bolívar fishers would toss over to them from their boats. Eventually, some of the Puerto Roma fishermen inquired about the methods used by their downstream counterparts, and the Puerto Bolívar fishers shared information about the type of fishing nets and the plastic tubes they use.

However, unlike the relationship between Puerto Bolívar and the Jambelí Archipelago where knowledge and work are shared as part of kinship networks and work relations, the connection with the people of Puerto Roma lacked this close bond. Knowledge mobility occurred not through collaboration, but through distant observation. In fact, while on a fishing trip during fieldwork, one Puerto Roma fisherman was using the tube to listen for sea bass but admitted he could not recognize the sound. This confession, later echoed by other fishermen, confirmed that the method had not been fully taught to them.

Through their experience of moving upstream over the past four years, the fishermen of Puerto Bolívar have developed a deep understanding of the differences between fishing downstream in the open sea and upstream in the inner estuary. In their local waters around Puerto Bolívar, where they say depths reach around 10 meters, they cast their nets and wait for the fish to become entangled, as the vastness of the open sea means that fish are more dispersed. This method of fishing is slower, requiring more time for the catch to accumulate. However, upon moving upstream to Puerto Roma, where the waters are narrower and shallower, with depths they estimate to be of 5–6 meters, they quickly realized that fishing could be faster. The confined space of the estuary makes it easier to locate fish, allowing them to haul in their nets more quickly. This contrast in fishing conditions led the Puerto Bolívar fishers to adapt their techniques, optimizing for speed in these new, narrower waters.

The adaptation of Puerto Bolívar fishers has not gone unnoticed by their counterparts in Puerto Roma. In recent years, two distinct groups have emerged within the Puerto Roma fishing community. The first group, comprising around 25 fishers, has fully embraced the techniques they observed from Puerto Bolívar. They have adopted the same "electronic" nets and added weights to ensure the nets reach the necessary depths for catching sea bass, just as the Puerto Bolívar fishers do. When Puerto Bolívar fishers arrive in Puerto Roma, this group closely follows them, positioning themselves at a discrete distance to observe their methods. Although they have purchased plastic tubes, they do not yet recognize the sound of the croaker; therefore, they wait for the Puerto Bolívar fishers to cast their nets before they also throw their nets into the water. They also replicate the fast retrieval of the nets, a hallmark of the Puerto Bolívar fishers' upstream adaptation. In contrast, the second group, consisting of approximately 18 fishers, has chosen to remain loyal to their traditional mangrove fishing methods. They use lighter weights and maintain a slower pace, casting their green textile nets and allowing for longer waiting periods before hauling them in, adhering to the practices that have been passed down from generation to generation in the mangroves.

In Table 2 we summarize the characteristics between the three types of fisheries that we cover in this article, and we describe their consequences for the environment: the *bolicheros*, the fishers of Puerto Bolívar who have adapted their local knowledge (including the ones in Puerto Roma who imitate them), and the fishers from Puerto Roma who continue to use ancestral knowledge of the mangroves.

Table 2. Differences in the fisheries and the vessels operating in interior waters in the Gulf of Guayaquil.

Characteristic by vessel type	Open-sea semi-industrial vessels (*bolicheros*)	Artisanal vessels from the South (Puerto Bolívar; local open-sea knowledge)	Artisanal vessels from the North (Puerto Roma; mangrove-ancestral knowledge)
Ship length	100 meters (Puerto Bolívar)–200 meters (Posorja)	Mostly 7.30 meters	Between 6 and 7 meters
Detector device	Radar	Plastic tube	None
Detection of the fish shoal	Find the fish shoal using radar	Find the fish shoal by putting a plastic tube in the water and hearing the sound of the fish	Based on the tides, the application of knowledge is handed down from generation to generation by word of mouth or by observation and gesture (Crean & Symes, 1996, p. 112)
Technique	They use trawl nets for catching fish and then hoisting them up using pulleys, making the fishing process more efficient	They surround the fish with the fishing net and make a noise with the motor to force the fish to gag	They go with the boat, pull the nets, and fish in a straight line
Type of gear	Small-mesh fishing net: 0.5 inches and bigger	Medium-mesh fishing net: 3.5 inches and bigger	Large-mesh fishing net: 5 and 6 inches
Consequences of using the type of gear	Highly predatory because it catches all fish possible (including juveniles)	Catch small and bigger fish but it functions at a much smaller scale than industrial techniques	Non-predatory because it only catches bigger fish
Consequences in the seabed	The *bolicheros* fish with large nets and tend to scrape the seabed	They fish by paying attention to the depth of the different parts of the Gulf and adapt their techniques so as not to scrape the seabed	They do not fish deep and there is no risk of scraping the seabed
Dynamic of fishing	Quick removal with pulleys	Quick removal with their hands	Slow removal with their hands
Quantity caught	2,000–12,000 croakers	100–300 croakers	Up to 100 fish

5.3. The Other Side of the Coin: The Small-Scale Fisheries Conflict

During fieldwork in the waters of Puerto Roma, the first author observed a conflict between vessels caused by entangled nets, which led to a dispute over the catch. At that moment, the most important thing for the fishermen was to finish their work in that spot by continuing to search for another shoal in the waters. Amid

insults from both sides, one of them decided to take out a knife to cut the nets and take the catch. The other fisherman was left with a damaged net and expressed his frustration over the loss. The cost of repairing a fishing net depends on the damage but can range between $100 and $200 while losing one means having to purchase a new net, which can cost between $1,000 and $1,200 (sometimes they must buy a new net if it gets lost in the water with the tide).

In the information gathered during fieldwork, it was documented that, on some occasions, fishermen coming from Puerto Bolívar fired shots into the air before or during the collection of their nets, intending to deter others from approaching their catch. A common fear within the community of Puerto Roma is that criminals may infiltrate the groups of fishermen from Puerto Bolívar. The dynamics of how these criminals operate involve intimidating fishermen into handing over their catch or threatening them with weapons to force the surrender of both their catch and the engines of their boats. These situations have been documented in a newspaper article (Carrión, 2021) and are mentioned in this article as part of the narrative regarding the conflict dynamics unfolding in the Gulf of Guayaquil.

5.4. The Subtle Resistance of the Mangrove-Ancestral Fishers

Currently, in Puerto Roma, opinions about the Puerto Bolívar's practices are divided. Though the community mainly gathers crabs, fishing is crucial for some families during the closed crab seasons (February and August) as an alternative source of income. Climate variations and other factors can affect crab populations, putting pressure on fishing resources, highlighting the importance of this research in analyzing alternative and potential sources of income and conflict.

The mangrove-ancestral fishers in Puerto Roma, numbering about 18—with some of them fishing for about 40 years—use green nets with 5–6-inch mesh sizes to catch only larger fish, and they fish slowly. They describe their way of fishing as *más tranquila* (more peaceful/relaxed), indicating that they "go fishing according to the tide," and they say when Puerto Bolívar's fishers do not come for several days "there are more fish" (Participant 7, focus group). In their own words, they could rely on fishing until four years ago, before the arrival of fishers from Puerto Bolívar, now "the fishery is running out" (Participant 8, focus group). In their opinion, newcomers' boats initially caught 100–200 croakers each, depleting the fish population. Ancestral fishers believe the newcomers' smaller nets (3.5 inches) catch juvenile fish, and hence consider them "predators" who take fish that should mature over 5–6 months. They have been spectators of the fact that other people of Puerto Roma have bought the same nets as the Puerto Bolívar's fishers and now imitate their practices. However, they resist adopting these methods, believing them short-sighted:

> Because it would be thinking only for today and not for tomorrow. And those who come after us, what are they going to live on? The children, the grandchildren. Everything is coming to an end, we feel the consequences of that type of fishing, not them. (Participant 7, focus group)

Unlike the crabbers, mangrove-ancestral fishermen are not organized as a group of fishers. The Association of Crabbers has been an institution with a trajectory since 2012 when they started managing a mangrove area that was granted for stewardship and sustainability as a concession by the Ecuadorian government. As an institution, they have a management plan for the area. To comply with it and manage the institution, they charge a fee to its members. They are equipped with radios and organize guard shifts for surveillance, unlike

the ancestral fishermen. The ancestral fishermen admit that, when they are fishing and fishermen from Puerto Bolívar arrive unexpectedly, they often choose to "pick up their nets and leave" due to their fear, stating, "They stop us from working" (Participant 8, focus group). Additionally, they worry that among the groups of Puerto Bolívar fishermen, thieves may also appear to steal their belongings and may even carry weapons.

In their families, other members are dedicated also to fishing or domestic labor, selling fish in the city market, and other activities. Hence, family work is essential for their sustainability. Mangrove-ancestral fishers know fishermen from other communities who also fish ancestrally and maintain cordial relations, greeting them from their boats when they meet. Though encounters happen in an unplanned way, when they see each other, they coordinate the depth to which they will cast their nets to avoid conflict. They stated that nobody would cause damage to others if all of them cast their nets in an organized way so that they would not become entangled. Their nets are of the same size, covering 3–4 varas long. The vara is a measure of length with colonial origins, that has been adopted and adapted by fishing communities in Latin America. The vara measures approximately 0.80–0.84 meters. Its use reflects both cultural heritage and a practical adaptation to fishing practices. We write here varas and we do not change it to another metric system because it serves as the standard measure for fishers when referring to the length of their fishing nets.

In Figure 4, we illustrate in orange two trips conducted during fieldwork with the fishers from Puerto Roma (on May 22, 23, and 31, 2023), while following the Puerto Bolívar fishers. These trips involved traveling long distances and conducting fast fishing to the north (12.7 km) and to the south (18 km) in search of the shoal. In turquoise, we depict a trip with a traditional mangrove fisherman, covering shorter distances (6.7 km) and practicing slow fishing in the waters of Puerto Roma.
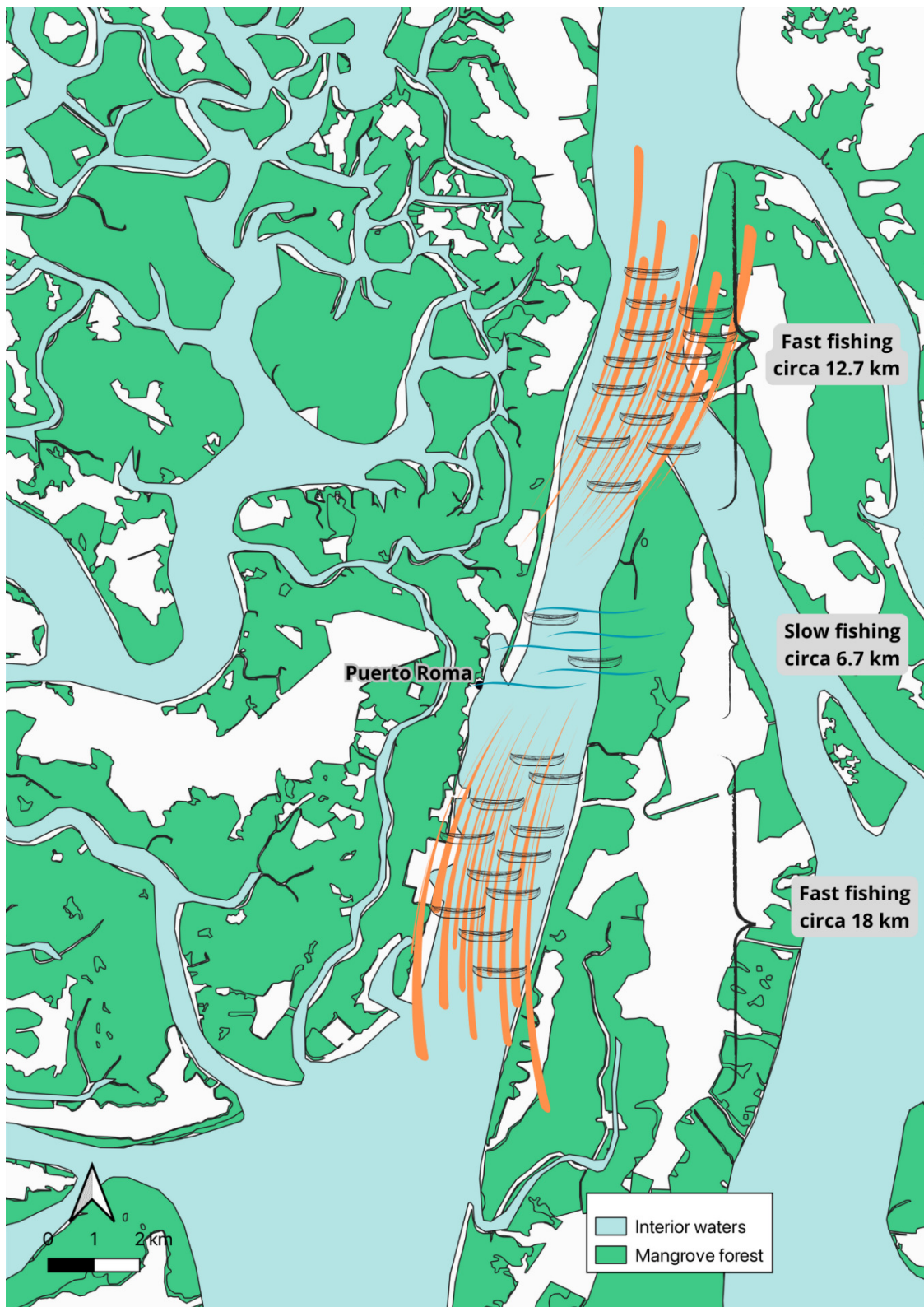
Figure 4. Zoom in on the fast and slow fishing in the Interior Central Estuary of the Gulf of Guayaquil. Note: The arrival of the southern fishers from Puerto Bolívar has caused a differentiation among the fishers of Puerto Roma. Some join the Puerto Bolívar's fishers in their quest for croakers, following them, traveling long distances up and down the Interior Central Estuary, and fishing fast (orange curves), while others continue to use mangrove-ancestral methods and slow fishing (turquoise curves).

6. Discussion and Conclusions

This study has provided substantial insights into how illegal institutional arrangements and criminal activities drive the forced displacement of fishers in the Gulf of Guayaquil. It also highlights that, despite these challenges, fishers actively contribute to epistemic mobility as they adapt to new contexts and navigate conflicts. By comparing theoretical frameworks with empirical data from fieldwork, we demonstrate how knowledge mobility is influenced by these institutional and socio-economic conditions. This understanding ultimately advances our knowledge of coastal and fisheries management dynamics.

In line with the conceptual framework's emphasis on institutional arrangements as both formal and informal practices guiding social interactions (Olivier & Schlager, 2022), our results confirm how these frameworks can breed illegal practices like corruption (Nunan et al., 2018). The illegal encroachment of industrial vessels, or *bolicheros*, into zones reserved for small-scale fishing—protected by bribery and criminal gangs—illustrates the prevalence of weak enforcement and non-compliance (Sundström, 2016). The findings of our study support the theories of Gezelius and Hauck (2011) and those of Sundström (2016) by providing further evidence that corruption and bribery within the Navy enable these illegal activities to persist, exacerbating resource conflicts and driving the displacement of artisanal fishers.

Hornidge et al. (2020) explain that epistemic mobility entails the movement and transformation of knowledge, which becomes semi-stable and adaptable across different contexts. Our study expands on this by demonstrating how displaced fishers from Puerto Bolívar carry not only their fishing techniques but also an embedded knowledge system shaped by their interactions with the open sea. When these displaced fishers migrate to upstream communities like Puerto Roma, they introduce their more advanced fishing techniques, such as the use of plastic tubes to detect sea bass shoals. However, the transfer of southern fishing techniques to the north can contribute to overfishing in their new locations. This means that, while our study highlights the role of epistemic mobility, forced displacements may complicate resource management and contribute to depletion in destination areas.

Reflecting on epistemic mobility, it is important to recognize that the movement of knowledge can encounter significant barriers and misinterpretations. In Puerto Roma, knowledge was not fully integrated but functioned through distant observation, where fishers replicated the actions of Puerto Bolívar fishers without fully understanding the techniques. This is evident in their use of plastic tubes: While Puerto Roma fishers imitated the method by placing the tube in the water and listening, they were unable to discern the sounds of the fish as the Puerto Bolívar fishers do. This demonstrates how epistemic mobility does not always result in effective learning but can lead to the adoption of techniques without mastery. Such incomplete or misunderstood knowledge aligns with Ruddle's (1994) concept of hybridized knowledge, where external methods are blended with local practices, often resulting in uneven or partial outcomes. However, as epistemic mobility is a dynamic process, it remains possible that, with more prolonged interaction and/or stronger relationships between the two communities, a deeper understanding and mastery of the techniques could develop, suggesting that this learning process is still ongoing and open to evolution.

Following the mobility paradigm (Sheller & Urry, 2006) that focuses on the movement of people, ideas, and knowledge, our study demonstrates that this mobility also generates conflicts between small-scale fishers

themselves. These conflicts, as observed in Puerto Roma, not only stem from the tension between industrial and small-scale fisheries but also arise from competition among small-scale fishers. The displacement of Puerto Bolívar fishers into Puerto Roma's waters led to entangled nets and disputes over fishing grounds, highlighting the occurrence of conflict over resources. Also, the introduction of rapid fishing techniques by Puerto Bolívar fishers has caused a differentiation in Puerto Roma between those who adopt the new methods and those who resist them.

Building on Scott's (1989) theory of everyday forms of resistance, we observe that fishers who adhere to mangrove-ancestral knowledge in Puerto Roma quietly resist the pressure to adopt new fishing techniques. These fishers prefer to maintain slower, less invasive methods, continuing to rely on traditional knowledge passed down through generations. This form of resistance underscores the socio-cultural importance of ancestral knowledge in maintaining sustainable fishing practices in the face of external pressures. The resistance to the modern methods brought by displaced fishers from Puerto Bolívar shows that epistemic mobility is not a unidirectional or uncontested process; rather, it involves adaptation, and, at times, rejection.

This research advances the body of knowledge on fisheries management and epistemic mobility by highlighting the complex relationship between corruption, displacement, and knowledge mobility. Our findings extend the work of Sheller and Urry (2006) by demonstrating how mobility involves not only the movement of fishers but also the movement and transformation of their knowledge systems, which adapt to new socio-ecological contexts. The introduction of the concept of epistemic mobility in the context of fisheries conflicts offers a fresh perspective on how knowledge flows between local communities, emphasizing the hybridization of techniques and the resulting socio-ecological implications.

More research is needed to understand how illicit and criminal activities inland affect coastal areas. We refer specifically to the corruption and bribery between the navy and the fishing industry, particularly concerning semi-industrial vessels, as illegal. The analysis of the security issue in Ecuador is complex and encompasses various factors that we were unable to address in this article. However, we can state that both those providing illegal armed protection for semi-industrial vessels and those collecting the extortion fee known as *la vacuna* are linked to criminal organizations ("Supuesta seguridad de," 2023). In Ecuador, the 22 gangs operating as organized crime have been declared "terrorists" by the current president due to their transnational nature ("Puerto Bolívar: Guerra," 2024a; "La rebelión narco," 2024; "En casi 40," 2024b). We recognize that this issue has become increasingly pronounced and widespread in Ecuador ("4 gráficos que," 2024; Insight Crime, 2023), leading to harsher penalties for criminal activities ("El código penal," 2023; "Congreso de Ecuador," 2024). Despite this, there is a significant lack of academic research on how these organizations operate and their consequences for the Ecuadorian population and coastal communities, as this issue is primarily covered in newspapers and social media.

Another area that requires exploration is the analysis of the power dynamics surrounding the industrial fishing fleet. There is a lack of easily accessible data for researchers to determine who owns these industrial vessels or whether they are controlled by oligopolies. Additionally, when reviewing fishing policies, it is imperative to take action against corruption and engage in a critical self-assessment. While discussions about industrial fishing fleets often focus on foreign vessels illegally operating within Ecuador's 200-mile territorial waters, it is important to recognize that Ecuador's national fleet operates within the eight nautical

miles designated for only artisanal fishing. Despite this, although the issue receives media coverage, it remains inadequately addressed in academic discourse and governmental action. More comprehensive efforts are needed to highlight, and tackle, this critical aspect of the Ecuadorian fishing industry.

Overall, the dynamics described here illustrate how geographic phenomena are interconnected, as the behaviors and decisions of fishers in one region directly influence the ecological and socio-economic dynamics of nearby communities. In the Gulf of Guayaquil, the proximity of these fishing communities intensifies the effects of their interactions. Consequently, the ongoing conflicts arising from industrial encroachment should be understood as part of a broader tapestry of relational dynamics, where local decisions, resource management practices, and ecological impacts are inextricably linked. This understanding emphasizes the need for holistic fisheries management strategies that consider the interconnectedness of communities and the ecological systems they rely upon, rather than viewing each community's struggles in isolation. In conclusion, this research provides a nuanced view of the dynamics of fisher displacement, knowledge mobility, and conflict within the Gulf of Guayaquil. By linking empirical findings to theoretical frameworks on institutional arrangements, epistemic mobility, and resistance, we demonstrate how systemic corruption and criminal activities exacerbate the challenges faced by small-scale fishers.

Conflict of Interests

The authors declare no conflict of interests.

Data Availability

The information generated during this research is highly sensitive. If detailed information is required, the first author should be contacted to review whether this affects the integrity of the individuals involved.

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ARTICLE

Competing Knowledges and Sovereignties in the French Pacific Oceanscapes

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Abstract

In France, the notion of "deep-sea/deep-seabed" ("*grands fonds marins*") has emerged fairly recently in public policy discourse, and in particular in the wake of the 2009 Grenelle de la Mer, which marked the French government's desire for an integrated maritime policy. The Grenelle de la Mer is a public process of reflection and negotiation between the French government, elected representatives, economic and professional stakeholders in maritime affairs, and civil society, organized by the French Ministry for Sustainable Development and the Sea. *Grenelle* refers to the collective negotiation, initiated by the government in May 1968, with representatives of trade unions and industrial organizations, and held at the Ministry of Labor Headquarters in Grenelle Street in Paris. A national strategy regarding the deep-sea was developed in 2015 and updated in 2020 through a working group led by the General Secretariat for the Sea (under the authority of the prime minister), in which the authors of this article participated. This working group was made up of representatives from the relevant ministries, research institutes, and industry via the French Maritime Cluster. The French overseas territories were absent, even though the areas in question were mainly located in the French Pacific, which accounts for around two-thirds of the French exclusive economic zone (68%, 6.9 out of 10.2 million km^2). In addition, New Caledonia and French Polynesia have jurisdiction over their exclusive economic zones while Wallis-and-Futuna has no formal sovereignty in this area. France's maritime policy, and in particular its deep-sea strategy, is indicative of the relationship between the French state and its overseas territories, particularly in Oceania, marked by disregard, tension, and instrumentalization. This dynamic also extends to the knowledge issue and the lack of recognition of Indigenous voices in these matters. This article will analyze this situation of epistemic injustice while underscoring the differences and commonalities in the three territories' trajectories regarding the interplay between sovereignty, environment, indigeneity, and development.

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1. Introduction

Governance, understood in an exploratory and non-normative sense, encompasses the more or less coherent, more or less interconnected, more or less stabilized forms of regulation that emerge from interactions between actors and institutions in the private, public, and associative spheres, in relation to a particular social domain (Blundo & Le Meur, 2009). This social domain can vary significantly in scope and clarity depending on the context, as illustrated by discussions of "deep-sea governance," for example. Governance implies power relations that are riddled with knowledge issues. These are about pluralism, recognition, and categorization, in other words, visibility and invisibility, or rather mechanisms and strategies rendering things, ideas, and also knowledge and epistemologies, visible or invisible.

The social domain at stake here, the *grands fonds marins* (deep-sea/deep-seabed), has (re)emerged fairly recently in the French public policy discourse, and in particular in the wake of the 2009 Grenelle de la Mer, which demonstrated the French government's commitment to developing an integrated maritime policy. A national strategy regarding the deep-sea was formulated in 2015 and updated in 2020 through a working group led by the General Secretariat for the Sea (under the direct authority of the prime minister), in which the authors of this article participated as scientific representatives. A final report, that was not made public for no official reason (probably its politically-sensitive nature), was written by Jean-Louis Levet and transmitted to the French General Secretariat for the Sea in July 2020: *Stratégie nationale d'exploration et d'exploitation des ressources minérales dans les grands fonds marins*. The working group was made up of representatives from the relevant ministries, research institutes, and industry via the French Maritime Cluster, a formalized industry lobbying network. The French Overseas territories were notoriously absent, even though the areas in question were mainly located in the French Pacific, which accounts for around two-thirds of the French exclusive economic zone (EEZ; 68%, 6.9 out of 10.2 million km^2). In addition, New Caledonia and French Polynesia have jurisdiction over their EEZs covering 1.4 million and 4.8 million km^2 respectively, thanks to their institutional autonomy resulting from the 1998 Noumea Accord and 1999 Organic Law for New Caledonia and the 2004 Organic Law for French Polynesia. This is not the case for Wallis-and-Futuna, which has no formal sovereignty in this area.

France's maritime policy, and in particular its deep-sea strategy, is indicative of the relationship between the French state and its overseas territories, particularly in Oceania, marked by disregard, tension, and instrumentalization. This also extends to the knowledge issue and the lack of recognition of indigenous voices in these matters. The campaigns carried out by the French government in 2010–2012 in Futuna waters in the wake of the 2009 Grenelle de la Mer were private-public partnerships involving national research and corporations (Areva, Technip, and Eramet), which reflected a political economy of science that marginalized Pacific representation and knowledge of the oceanscapes (Ingersoll, 2016). More broadly, the very notion of deep-sea/deep-seabed implies separations (land vs. sea, deep-sea vs. coastal sea, and sea vs. seabed) that contradict the Oceanian, holistic vision of a continuum including land, sea, air and the sky, and peopled by human and nonhuman actors (Childs, 2022).

These mechanisms display a pattern similar to what we observe in the Pacific at large in terms of North–South relations. There are discrepancies and contradictions between an Indo-Pacific strategy, promoted in particular by the US, the so-called "Free and Open Indo-Pacific" (Department of State, 2019), with the "Silk Roads" as a Chinese alternative, and taken up by its allies (including France), and a desire for regional autonomy expressed by the Blue Pacific discourse, which has taken the form of a geopolitical strategy, formalized by the Pacific Islands Forum in 2017 (Kabutaulaka, 2021; Louey, 2024). This discourse is rooted in the Pacific Way of the 1970s–1980s. The expression was probably first used publicly by the Fijian prime minister, Ratu Sir Kamisese Mara, in front of the UN General Assembly in October 1970 (Lawson, 2010; see Fry & Tarte, 2015, Chapter 6, for a contextual analysis of the notion of "Pacific way"). The Blue Pacific discourse is also rooted in the paradigm shift proposed by Epeli Hau'ofa in the 1990s (Hau'ofa, 1994, 2000)—Pacific countries as Large Ocean States rather than Small Island Developing States (SIDS). This paradigm shift is explicitly both a political and knowledge issue, raising questions of environmental and epistemic (in)justice (Fricker, 2007, 2013) that lie at the center of the regional dialogue platform we organized on behalf of IRD at the Pacific Community (SPC), Noumea, in March 2024 with political, customary, administrative, civil society, research, and regional organization representatives from around 15 Pacific countries and territories. A second platform took place in Tahiti, at the University of French Polynesia, in December 2024, both events being part of a collective scientific assessment on deep-sea knowledge and governance issues (see further down on this section).

The entanglement of governance, knowledge, and justice issues is addressed here through the lens of the deep-seabed, a key, complex, and contested issue on a global scale, as well as in the context of the Island Pacific and the Indo-Pacific promoted by the French state in search of a hypothetical "third way" between the US and China (Perrin & Temal, 2023). Section 2 lays the theoretical ground of our approach to knowledge and governance especially through the perspective of epistemic justice. Section 3 presents the recent changes in the French deep-sea policy. Section 4 analyzes the differences and commonalities in the trajectories of the three French Pacific territories regarding the governance and knowledge of the deep-sea.

The data and interpretations presented in this article stem from our participation in successive scientific assessments in French Polynesia (2014–2016), Wallis-and-Futuna (2018), and New Caledonia, along with the two latter territories (2023–2026); long-term, still ongoing ethnographic research; and observations (partly participants) and interviews with various stakeholders, which we carried out within and around these projects over the last 10 years. The current scientific assessment focusing on the three French Pacific territories operates on the basis of a scientific panel composed of 13 researchers (6 women and 7 men) from French research institutes and universities (2 economists, 2 biologists, 1 oceanographer, 2 geoscientists, 1 philosopher, 2 lawyers, and 3 anthropologists), two of them from the Pacific, and a steering committee including political and customary representatives from the three Pacific territories, representatives from French ministries, scientists, and NGO members.

2. Indigenous Knowledge, Epistemic Justice, and Ocean Governance

The paradigm shift from SIDS to Large Ocean States is a clear assertion of a sovereignty claim. Here we follow Joyce (2013) who locates sovereignty within a triangular relationship with community and law paving the way for plural and competing sovereignties and plural visions of community-making assemblages and ontologies, including a relational ontology linking humans and nonhumans, gods, and ancestors in Oceanian lifeworlds (Le Meur & Mawyer, 2022; Tomas, 2013). The shift from SIDS to Large Ocean States thus also

implies a shift in the representations of the oceanscapes and the recognition of Pacific visions, which are both a matter of epistemology and ontology (Ingersoll, 2016). It is precisely at the intersection between epistemology and ontology that the scope of Indigenous knowledge is situated. The sophisticated knowledge Pacific islanders have developed over the years about oceanic currents, winds, climate, bird movements, astronomy, and island geography is now well-known (D'Arcy, 2006; Lewis, 1972). This knowledge results from partially cumulative observations and experiences. It also implies indirect forms of knowledge, such as when it comes to seamounts. What is known is fishing grounds (tuna, skipjack, and demersal species; see Misselis & Ponsonnet, 2015, for French Polynesia) or places where humpback whales or other species gather on a seasonal basis rather than seamounts per se. However, seamounts are also named and oceanic toponyms often reflect terrestrial ones as seen in the Austral Islands in French Polynesia (Dégremont & Bambridge, 2015) or the Coral Sea surrounding New Caledonia (work in progress carried out by the Customary Senate and the Agency for the Advancement of Kanak Culture, also showing ruptures and losses in this knowledge due to the colonial repression of natives' mobilities and especially navigation). Indigenous knowledge matches scientific results on these issues (for instance, Morato et al., 2010, estimate that between 1997 and 2007, almost 40% of French Polynesia's yellowfin tuna catches were made on seamounts) or at least, both can be compared on a common ground from an epistemic viewpoint that favors empirical observation. However, this does not mean they are based on the same epistemologies. For instance, oceanic knowledge developed by Pacific navigators involves a dynamic topography, composed of moving and sometimes living "seamarks," that contrasts with the Western notion of fixed cartography (Goodenough & Thomas, 1989).

Nevertheless, when it comes to representing the seabed as harboring the souls of the dead, as we will see in the case of Kanaky-New Caledonia, the limits of knowledge as a concept are called into question. This is not a matter of knowing whether dead souls live around seamounts or not. It is about belief, cosmology, and ontology. It actually belongs to the domain of sovereignty, as previously defined based on a relational ontology (and can serve as a basis for heritage policies). In other words, the vast domain of Indigenous knowledge and representations may be a key component of ocean governance apparatuses and conflicting sovereign claims (Le Meur & Mawyer, 2022). This involves political negotiation and power asymmetries, as we will see with the French Pacific cases.

Inclusiveness is central to this issue—it requires acknowledging power imbalances, involving all stakeholders, and valuing the diversity of their knowledge and perspectives, making it a question of epistemic justice. Epistemic justice, or rather injustice, is about the unequal distribution and recognition of cognitive abilities, leading to the marginalization and silencing of certain knowledge and its holders. Miranda Fricker's (2007) seminal book, *Epistemic Injustice: Power and the Ethic of Knowing*, makes a distinction between testimonial and hermeneutical injustice. Epistemic injustice occurs in the case of a "wrong done to someone specifically in their capacity as a knower" (Fricker, p. 1). Fricker speaks of testimonial injustice when:

> Prejudice causes a hearer to give a deflated level of credibility to a speaker's word; hermeneutical injustice occurs at a prior stage, when a gap in collective interpretive resources puts someone at an unfair disadvantage when it comes to making sense of their social experiences. (Fricker, 2007, p. 1)

Epistemic injustice may thus take different forms that do not necessarily result from conscious strategies, such as making the deep-sea visible through sophisticated techno-scientific mediations that mechanically

render invisible (or less visible) other ways of knowing and representing the abyss. The contemporary dominance of the scientific viewpoint can in this sense lead to forms of epistemic injustice, making other ways of knowing the ocean less relevant, especially regarding governance and decision-making. This is a structural form of hermeneutical injustice "performatively produced" (Medina, 2017, p. 45–46), yet operating beyond the awareness of the actors involved. This is particularly true for Indigenous knowledge of the deep-sea, especially when it pertains to beliefs and myths, which are more likely to be perceived as lacking credibility (as Fricker, 2007, puts it) in the so-called evidence-based policy processes. Indigenous knowledge of the deep-sea is heterogeneous in nature: it comes from indirect experiences of deep-sea phenomena that produce effects on the surface (what happens around deep-sea mounts for instance), from a direct experience of the ocean as a place for sailing and fishing (a holistic view that does not align well with the scientific and legal divisions of the ocean), and it manifests itself through practices as well as discourses (with particular patterns of social and intergenerational transmission) that constitute Indigenous oceanscapes. Any attempt to disengage this holistic vision from its fundamentally social and political Indigenous value may lead to epistemic injustice in that it could erase Indigenous views, which are seen as outdated folklore, in favor of science, seen as both universal and inherently good. This is a hermeneutical form of epistemic injustice, occurring "when someone is wronged in his or her capacity as a subject or source of understanding" (Tsosie, 2017, p. 360). Such a stark division (science as the only good on the one hand, Indigenous knowledge as a useless but decorative object on the other hand) is an active colonial legacy that undoubtedly affects contemporary governance issues regarding the ocean and sovereignty claims surrounding it. Understanding the inevitable entanglements of knowledge and politics and whatever type of knowledge is involved, allows the discussion to be reframed by shifting away from the intrinsic value of knowledge (with scientific knowledge perceived by many, including some members of the Indigenous communities, as the most well-equipped to provide data in contemporary debates) to its social and political relevance (Indigenous sovereignty being the underlying issue at stake).

3. France's Deep-Sea Strategy: Changing Tide and the Overseas Blind Spot

The work to update the French deep-sea strategy for 2019–2020 was focused on the primary objective of exploring and exploiting deep-seabed mineral resources. In particular, the aim was to support the development of a national mining operator in this sector and an industrial pilot project. A collective scientific assessment was planned to take stock of knowledge and stakes in this field, along the lines of the one carried out in 2014–2016 in French Polynesia. This collective scientific assessment officially started in June 2023 and the results will be published in the first semester of 2026. It is financed by the Maritime Intervention Fund of the French Secretary of State for the Sea and carried out by French Research Institute for Sustainable Development (IRD). The authors of this article co-chair its multi-disciplinary panel of experts, now called upon to work not simply on the issue of mineral resources (which the French government's previous position might have reduced the work to), but more broadly on the issues of knowledge and governance of the deep-sea, in the French Pacific EEZ, and the Clarion-Clipperton Zone (administrated by the International Seabed Authority) in the northern Pacific (https://www.ird.fr/lancement-de-lexpertise-grands-fonds-marins). All of this was in line with the national deep-sea strategy. The inclusion of basic scientific research (which was to materialize as part of a state-funded, multidisciplinary nine year inter-disciplinary research program on the deep-sea from the seabed to the water column) only gradually emerged from the discussions.

The French president's change of direction toward a strict ban on deep-sea mining, on June 30, 2022, at the UN Ocean Conference in Lisbon, was to be a game-changer. The change was unexpected and not concerted within the government. In fact, at the World Conservation Congress of the International Union for Conservation of Nature in Marseille in September 2021, France "did not want to approve the resolution calling for an end to deep-sea mining. Improving scientific knowledge about the deep-seabed requires expeditions to be carried out there," argued the head of state at the time (Valo, 2022, para. 8).

For the time being, it is difficult to interpret this turnaround with any certainty. However, we can put forward several hypotheses, which may overlap and which time will ultimately confirm or disprove—a question tied to the politics of time (Childs, 2020; Kirsch, 2014; Le Meur et al., 2018). The first hypothesis is that the promises of deep-sea mining appear too uncertain or remote in economic and technological terms and that it is less risky, and politically more profitable, to promote ocean conservation—aligning with the scientific community concerned about environmental issues. The second hypothesis refers to the French government's desire to make its voice heard diplomatically on a global scale, in this case, by proposing a broad international alliance in favor of a ban or moratorium on the exploitation of deep-sea mineral resources. The third, more cynical hypothesis is to wait until extraction technologies have reached a sufficiently mature stage, and, in the meantime, position itself as a champion of ocean protection. In all cases, this turnaround has brought the French position into line with that of the three Pacific territories, which could fuel a fourth hypothesis, namely the refusal to "force the issue" in the face of these territories' hostility to seabed mining, in order to avoid undermining an already delicate (post)colonial balance. Recent examples include the difficulties encountered in the public debate on the consequences of nuclear testing in French Polynesia and the challenges facing the French government's attempts to unfreeze the electoral body in New Caledonia. A fifth, and final hypothesis, would be the influence of campaigns and lobbying led by organizations and people such as French climate activist Camille Etienne, as suggested by Anne-Lise Boyer (2024).

One thing is certain though: the only knowledge referred to here is scientific knowledge. By acknowledging a "knowledge gap" about the deep-sea (and presenting it as the main argument for opposing deep-sea mining projects), the French state intends to support its public scientific research, while Indigenous knowledge about the ocean is being rendered invisible, treated as useless in a debate narrowly framed around the state (that makes decisions regarding the exploitation of resources in its national space) and science (that might help the decision-making process by collecting and analyzing data). However, the Pacific Ocean is inhabited by populations who have built valid knowledge about the sea, as well as perceptions of this space that are intrinsically connected to ideas of autochthonous sovereignty. This seems to be inaudible in a tense postcolonial (or at least post-imperial, see Howe, 2000, p. 97) context. We will not engage in the debate between postcolonial and decolonial studies, which is beyond the scope of this article and deserves thorough historicization, careful reading, and nuanced appreciation (Coronil, 2019, Part III; Escobar, 2018; see also Boidin, 2009, for a good overview for a French-speaking audience). We instead focus on the enduring coloniality of power that pervades the relationships between the French government and Pacific overseas territories. The distinction between colonial relations and colonization, proposed by Benoît De L'Estoile, proves useful here. He defines colonial relations as:

> A set of related forms that have structured the interactions of Europe with a large part of the rest of the world between the 15th and 20th centuries…including conquest, rebellion and repression,

religious mission, scientific exploration, education and medical care, trading and economic exploitation, travel, art, population transfers, etc. Colonial relations, often stamped by domination and violence, are however more aptly characterised by a multifarious process of appropriation than by the sheer negation of the colonized....By contrast, colonization describes the political control of a territory by a foreign power with a view to incorporation and exploitation (but not necessarily including settlement); in that sense, colonization is but one possible mode of colonial relations. (De L'Estoile, 2008, pp. 268–269)

We must add that settler colonization, as in New Caledonia (contrasting with French Polynesia and Wallis-and-Futuna), has historically involved a latent genocidal dimension (Veracini, 2024; Wolfe, 2006).

The question of the deep-seabed is indeed indicative of France's relationship with its Pacific territories. There are several reasons for this, stemming from both global geopolitics and France's colonial heritage. At the heart of the debate is the "discovery" that France could become a maritime power thanks to the size and distribution of its EEZ, second only to that of the US. This prospect, made possible by the 1982 UN Law on the Sea, which created the EEZs, and the presence of archipelagos in all three oceans that are still French, was expressed in a somewhat contradictory way, between the promotion of marine protected areas (to meet the Aichi Target resulting from the Convention on Biological Diversity), the orientation toward deep-sea mining (until 2022), and geopolitical discourse on the Indo-Pacific. Above all, it has often disregarded the autonomy of French territories, particularly in the Pacific. Both New Caledonia and French Polynesia have statutes giving them jurisdiction over their EEZs (via the 1999 and 2004 organic laws respectively), while military jurisdiction and maritime surveillance issues remain the responsibility of the state. This is not the case for Wallis-and-Futuna, however, whose non-sovereignty is enshrined in the 1961 statute.

4. The Deep-Sea as Viewed From the French Pacific Territories

If we are to understand France's deep-sea and Indo-Pacific strategy and its limits regarding the integration of Indigenous knowledge and Indigenous sovereignty claims, we need to uncover the blind spots in the Pacific overseas territories.

4.1. New Caledonia: Terrestrial Resource Nationalism but Deep-Sea Mining Refusal

The deep-seas of New Caledonia have been the subject of scientific and economic exploration campaigns for half a century. The scientific campaigns led by the Office of Scientific and Technical Research Overseas (ORSTOM that became IRD in 1998) began in the 1970s–1980s. They were followed by the ZONECO program (1991–2014) involving research institutes, the French state, New Caledonia, and the three Provinces (Staszak et al., 2022, p. 42). The ZONECO initiative focused on the mineral and living resources of the New Caledonian EEZ, and was designed to continue building the mineral inventory initiated by ORSTOM, but was ultimately limited to identifying potential zones of mineral resource presence (Staszak et al., 2022, p. 42). Oil companies also began looking for hydrocarbons in the 1980s but to no avail.

New Caledonia's political and legal framework was established by Organic Law No. 99–209 of March 19, 1999. It gives the territory jurisdiction over exploration and exploitation in its EEZ. Under Article 22 of the 1999 Organic Law (République Française, 1999), New Caledonia is responsible for the following matters:

"10°. Regulation and exercise of rights to explore, exploit, manage and conserve the natural, biological and non-biological resources of the exclusive economic zone....11°. Regulations relating to hydrocarbons, nickel, chromium, cobalt and rare earth elements" [translation by the authors]. However, New Caledonia's Mining Code (2009) does not address seabed mining activities in the EEZ.

The creation of the Parc Naturel de la Mer de Corail (PNMC, in English Natural Park of the Coral Sea) in 2014, which covers the whole of New Caledonia's EEZ, changed all that. It was preceded by a strategic analysis of New Caledonia's maritime space (Gardes et al., 2014), which mentions the deep mineral issues at stake, clearly underlining the very limited scientific knowledge on the subject. Staszak et al. (2022, p. 44) make a similar observation regarding deep-sea mineral resources. The establishment of the management committee in 2015, and the scientific committee in 2018, the validation of the first management plan in 2018 following a consultation process, and the country's law of June 1, 2022, on the protection of New Caledonia's marine areas, firmly established the PNMC within the local institutional framework. Significantly, the decrees governing its operation have all been unanimously adopted by the New Caledonia government, which operates on a collegiate basis and brings together the various pro-independence and anti-independence political perspectives.

The issue of deep-sea mineral resources (and also hydrocarbons) has taken a back seat since the creation of the PNMC, and the "civil society" college of the management committee—comprised of environmental associations and NGOs—has supported this state of affairs. At the 5th France-Oceania Summit on July 19, 2021, Louis Mapou, president of the government of New Caledonia, insisted on "the need to preserve the great marine balances, both for the exploitation of fisheries and for the exploitation of underwater resources, for which a moratorium seems to be necessary," while the French president remained silent on the subject (see https://la1ere.francetvinfo.fr/polynesie/tahiti/polynesie-francaise/5eme-sommet-france-pacifique-vers-un-renforcement-de-la-cooperation-avec-les-etats-d-oceanie-1061959.html). It is worth noting that for pro-independence parties, terrestrial nickel mining and processing serve as the key economic driver for political sovereignty (Le Meur & Levacher, 2022; Neaoutyine, 2006). A bill to introduce a 10-year moratorium on the exploration and exploitation of deep-sea mineral resources in the EEZ was unanimously adopted by the government of New Caledonia on June 7, 2023, and is due to be ratified by Congress in 2025. The preliminary draft law was the subject of opinions from the various colleges of the PNMC management council and from scientists (see Gouvernement de la Nouvelle-Calédonie, 2023a). This text also draws on the brief report written by Sarah Samadi, Pierre-Yves Le Meur, and Julien Collot: *Expertise extérieure pour le Comité Scientifique du Parc Naturel de la Mer de Corail au sujet du Projet de Loi de Pays portant moratoire sur l'exploration et l'exploitation des ressources minérales de la ZEE de la NC*, which notably helped refine the notion of exploration, distinguishing between scientific exploration (to be encouraged while addressing its potential impacts) and exploration for economic purposes or prospecting, to be banned.

At the same time, the Customary Senate, which participates in the PNMC management board, is developing the Kanak Cultural Vision of the Ocean, which aims to change the paradigm of the relationship between humans and the environment, and to place at the heart of the debate a holistic point of view that integrates the deep-sea into a wider oceanic space, and beyond that, into a land–sea continuum and a social organization integrating living humans and ancestors, biotic, and abiotic elements—as shown in the presentation by Jean-Yves Poëdi, customary senator, at the regional dialogue platform on deep-sea knowledge and governance organized by IRD at SPC, Noumea, March 19–21, 2024, to delegates from

around the 15 Pacific states and territories (Institut de Recherche pour le Développement, 2024). In this Kanak cultural vision, the ocean is seen as harboring the souls of the dead, in specific places that form a sacred path. This argument is put forward by critics of integrating Indigenous knowledge into public policy as proof that Indigenous knowledge is useless folklore. However, in this case, the question is not to know whether the souls of the dead are or are not under the sea. Such a claim stands as legitimate when it comes to governance discussions: sacred places constitute heritage, cultural assets that are acknowledged at all levels of governance, from local to supranational.

Moreover, the opinion of the Customary Senate on scientific exploration remains reserved—"we don't question nature, we listen to it, we feel it," (Jean-Yves Poëdi, 2024, communication at the Noumea platform) which aligns with a well-established Indigenous stance on maintaining a respectful relationship with the environment—even if it has shifted from a very restrictive view to now advocating for limiting scientific activity to matters that directly benefit society, such as research for medical purposes in particular. This attempt to control scientific research by orienting it towards medical research is crucial, as it helps envision the transposition of an indigenous view of the environment (which has long been integrating the knowledge of healing plants, for example) to the ocean as a potential source of still unknown healing substances. In this sense, Indigenous knowledge does not stand in opposition to scientific research.

The consensus uniting New Caledonia's political, customary, and civil society stakeholders is broad, but some areas of fragility can be identified, in particular, the duration of the moratorium to be included in the local law (*loi du pays*) is the subject of debate. The proposed 10-year period, which avoids certain constitutional contradictions with development objectives, is considered far too short by many, while the industrial lobby, represented by the Cluster Maritime de Nouvelle-Calédonie (an offshoot of the French Maritime Cluster), sees it as an opportunity to develop more efficient technologies that are less harmful to the environment, in order to make seabed mining "acceptable" (see the standpoint of the French Maritime Cluster at the first Conference on the Indo-Pacific maritime economy in New Caledonia organized by the New Caledonia Government, NC, and French Maritime Clusters on 25–27/10/2023; Gouvernement de la Nouvelle-Calédonie, 2023b). Deep-sea issues are also deeply entrenched in relations between New Caledonia and the French government, which are currently hampered by the latter's heavy-handedness and partiality in negotiations on the country's institutional future. The refusal of the president of the government of New Caledonia to attend the platform on the subject, organized by the IRD at the SPC in Noumea on March 19–21, 2024, is a reminder that the French strategy was drawn up without any consultation with the French Pacific territories.

4.2. French Polynesia: Contrasted Indigenous Perspectives Regarding Deep-Sea Mining

French Polynesia is an interesting case of rather successful integration of Indigenous knowledge into local marine policy regarding coastal areas. An ancient use of *tapu* (a term that refers, throughout the so-called Polynesian triangle, which includes French Polynesia, to what is forbidden or prohibited) applies to marine resources and is called *rāhui*. By reviving this practice (Bambridge, 2016) and implementing it in various places of the archipelago, French Polynesian authorities and people have shown that environmental policies are at the same time a matter of politics and knowledge. Deciding on a *rāhui* in a specific place or for a particular type of fishing resource might be based on environmental concerns (which often implies nowadays not only Indigenous knowledge of the environment but also scientific data to support the decision) as much as on

sovereignty claims (including territorial conflicts and micro-localized relations of power). Nevertheless, as for all the French territories in the South Pacific, French Polynesia's scope of action is restricted when it comes to its relationship with the French state and its relative positioning within the regional area.

Like New Caledonia, French Polynesia has jurisdiction over its EEZ, except for the regalian aspects of defense and surveillance, which remain under the responsibility of the French state. French Polynesia has gradually addressed the maritime issue, in particular in the search for alternative income sources to offset the economic (and unfortunately health) consequences of the nuclear tests that began in 1962 and were discontinued in 1996. In the 2010s, deep-sea mineral resources emerged as an option to be explored, leading to a collective appraisal commissioned by the government of French Polynesia and coordinated by the IRD. The conclusions of this work were cautious and nuanced, highlighting at the time (Le Meur et al., 2016, 2018) the major gaps in knowledge, the absence of industrial technologies and uncertain economic profitability. The government of French Polynesia has not gone any further on the subject, with the exception of a study entrusted to Abyssa (a subsidiary of Créocéan, a private consultancy agency specializing in oceanography and coastal development) in 2019 concerning the potential of cobalt-rich crusts on seamounts.

At the same time, French Polynesia has turned a corner in terms of maritime policy. After promoting large marine protected areas launched by the international NGO PEW in the Austral Islands and the state via the MPA Agency in the Marquesas Islands, the Polynesian government shifted in 2016 (when the autonomist Tapura Huiraatira party came to power) from a protection-based approach (marine protected area) to one focused on the management (marine managed area) of its entire maritime space. In 2018, it created the Tainui Atea area with the aim of "reconciling economic development and environmental protection" (Dégremont, 2022, p. 63). While expert assessment of the mineral resources mentioned in Section 1 took place during this period, the rationale for resource management remained focused on fishery resources (particularly tuna).

The Government of French Polynesia's position on mineral resources has since moved in the direction of a moratorium, but this trajectory has not been linear, and political parties have been divided by divergent viewpoints on the subject, such as the pro-independence Tavini Huiraatira party until 2022 when the Government of French Polynesia was preparing a draft deliberation for a "moratorium on deep-sea mining" (see https://www.tahiti-infos.com/Exploiter-ou-proteger-les-grands-fonds-marins-le-dilemme-du-Tavini_a211638.html). The internal debates within the Tavini party, which won the territorial elections of 2023 and now governs the country, are interesting because they mobilize a variety of arguments—environmental, political, economic, and also historical: "We're not the party that fought against nuclear testing to go and trash the ocean tomorrow" (Moetai Brotherson in 2022, then MP for French Polynesia; Pambrun & Samoyeau, 2022). Additionally, the geographical proximity of the Cook Islands, which have been developing a pro-extraction policy for almost two decades, is a source of local concern, on the one hand for the possible environmental impacts, and on the other for the potential positive economic spin-offs that could put French Polynesia in difficulty in justifying its pro-moratorium stance.

4.3. Wallis-and-Futuna: A Problematic Lack of Dialogue With Customary Authorities

The situation in Wallis-and-Futuna differs greatly from that of New Caledonia and French Polynesia in that the territory is entirely under the authority of the Prefect, the "head of the territory" according to the 1961 Statute, and who is the sole holder of executive powers. The state alone exercises sovereignty over the EEZ,

while local authorities, represented on the one hand by an elected Territorial Assembly and on the other by customary chieftaincies (one kingdom in 'Uvea-Wallis, and two in Futuna: Alo and Sigave), cannot claim a role in the decision-making process. A significant conflict exists between the political and legal segmentation imposed by the state, and subsequent to France's international commitments (UN Law on the Sea) for which the territory was not consulted, and the customary vision of maritime spaces, seen as a land–space continuum. However, land tenure in both 'Uvea (Wallis) and Futuna is still under the customary authority and strictly Indigenous (apart from a few cases, often conflictual, of land transfer for the installation of public infrastructure). The local population's current lack of understanding of the governance of maritime space is therefore a recent phenomenon, triggered by the state's desire to explore and exploit deep-sea mineral resources in Futuna (Le Meur & Muni Toke, 2021, 2022).

Following scientific-mining campaigns carried out in 2010, 2011, and 2012, as a public-private partnership involving Eramet, Areva, and Technip and run by Ifremer (French Research Institute for Exploitation of the Sea), the French government attempted to obtain the consent of the Territorial Assembly for a modification to the current mining code, to grant exploration and research permits to the industry (2014 and 2015). Since 2019, a text entitled Declaration on the Ocean has been under local discussion, with the aim of imposing a 50-year moratorium on the exploitation of deep-sea mineral resources and implementing a conservation plan for both the lagoon and the EEZ. This text has now been finalized and has been presented by the Territorial Assembly in Pape'ete at the second regional platform organized by IRD in December 2024.

Beyond political cleavages—particularly in 'Uvea, where a dissident chiefdom exists and federates a significant part of the population, alongside an official chiefdom recognized by the state—there is a local consensus against deep-sea mining that is publicly structured around the environmental argument. Nevertheless, it is closely linked to an explicit claim to sovereignty by the customary authorities, who are supported by the population in this regard. The idea that "Wallis-and-Futuna has never been colonized" has long been asserted, both in the territory and in the diaspora, and is now being challenged.

While President Macron's statement against deep-sea mining has helped to ease these political tensions, a strong demand for the inclusion of local authorities in decisions concerning the EEZ has now emerged and remains unresolved, the current political and legal framework not being in a position to accommodate it. The recent platform of regional exchanges organized in Noumea as part of the collective scientific assessment carried out by IRD on deep-sea governance and knowledge issues confirmed the clear expression of this demand for shared sovereignty, in an approach that acknowledges customary law, understood by the population and its chiefdoms as exercising undifferentiated rights over land and sea. This idea of a land–sea continuum is common throughout the South Pacific. Interestingly enough, it is not contradicted by geological data: the land does indeed plunge under the sea water only to resurface further as an island. Customary authorities in Wallis-and-Futuna defend this vision explicitly and express their concerns regarding contemporary supranational negotiations as well as negotiations including the French state and leaving them as spectators. They feel that their knowledge of the ocean, viewed as a pathway between islands (see Hau'ofa, 1994, 2000), with boundaries that should be discussed with other neighboring islanders (and not the French state, let alone the International Seabed Authority), is disregarded, along with their ancestral sovereignty over it.

5. Conclusion

In a speech delivered at the Lowy Institute in Sydney in 2018, the Hon Prime Minister Tuilaepa Sailele Malielegaoi made the following statement: "The renewed vigour with which a 'Free and Open Indo-Pacific strategy' is being advocated and pursued leaves us with much uncertainty. For the Pacific, there is a real risk of privileging Indo over the Pacific" (Malielegaoi, 2018).

This worrying observation by Tuilaepa Sailele Malielegaoi, then prime minister of Samoa, could be applied to the sometimes tense relations between France and its Pacific territories. It is set against a backdrop of competition, and even incompatibility, between the strategy of regional autonomy represented by the Blue Pacific and the promotion of an Indo-Pacific vision driven by partly external powers in the context of a global struggle for influence between US and China (and their respective allies). This tension is explicitly identified by the political representatives of the three French territories in the Pacific, whatever their political affiliation. In our interviews and fieldwork, we repeatedly heard remarks about the "Indo-Pacific" as a purely "French state" construct, built without consulting the territories (a fact that a recent report for the French Senate made clear, see Perrin & Temal, 2023) and thus perceived as both worrying and foreign to local governance practices, including customary ones. The feeling of being instrumentalized in a geopolitical game orchestrated from the outside is therefore expressed by actors of various statuses and political affiliations, which suggests both the necessity and appeal of a regional dialogue organized on an Oceanian scale (this is also a result of the regional dialogue platform mentioned in Section 1), within the context of a broader relational approach to security and sovereignty (Koro, 2023).

The relationship between the three territories and the French state has entered a phase of reconfiguration, following President Macron's recent announcement that the French government would renounce the mining of deep-sea mineral resources. The alignment of the three territories and the state on this common position should not, however, obscure the conflicts over the sovereignty of maritime spaces, which are still alive and ongoing despite relative political autonomy in New Caledonia and French Polynesia (Le Meur & Mawyer, 2022). The exploitation of mineral resources is obviously a central issue in discussions on sovereignty, but it is far from exhausting the subject, which is also made up of military issues relating to surveillance and the regulation of uses of the EEZ. The regional integration of France's three Pacific territories is a further challenge in this context. New Caledonia and French Polynesia have long-established relationships that have ensured they have the support of island states, particularly in their dealings with the UN (Fry & Tarte, 2015). This is illustrated by the agreements between New Caledonia and the Cook Islands about their respective large-scale marine protected areas in 2013 (at the governmental level) and 2016 (customary authorities; agreement extended to the Vanuatu Council of Chiefs), or the adoption by the Cook Islands in 2017 of the managed marine area model promoted by French Polynesia, as well as the 2015 declaration by the Polynesian Leaders Group claiming, via their contiguous EEZs, a marine area of 10 million km^2 called Te Moana o Hiva. The announcements by New Caledonia's customary and pro-independence authorities in favor of Vanuatu in the border dispute that has pitted this country against France for several decades over the Matthew and Hunter zone are also part of this trans-Pacific "political connectivity" (Dégremont, 2022), as is the proposal by Louis Mapou, president of the New Caledonian government, in his general policy speech on November 25, 2021, to make this disputed zone a "peace park," "which could be managed in consultation with the sister country, Vanuatu" (Mapou, 2021, p. 30). Nevertheless, the territory of Wallis-and-Futuna clearly remains on the fringes of regional dynamics. In this sense, the Blue Pacific strategy

remains a matter for independent states, in which the three non-sovereign Pacific territories must negotiate both an intra-regional position (which has a certain historical depth for New Caledonia and French Polynesia but remains to be built for Wallis-and-Futuna), and a degree of autonomy in their interactions with the French state. In this broad context, the politics of recognition needed to redress epistemic injustice, especially in its hermeneutical form, plays a key role in the various manifestations generated by the specific historical pathways of the three French Pacific territories.

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Conflict of Interests

The authors declare no conflict of interests.

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ARTICLE

Participatory Governance? A Critical Perspective on Stakeholder Knowledge Integration in the Context of German Baltic MPAs

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Abstract

The ocean is under increasing pressure from various human activities, including overfishing, pollution, and climate change. In response to these challenges, marine protected areas (MPAs) have emerged as important and widely applied tools for conserving and restoring marine ecosystems. Considering the complexity of identifying appropriate management measures and the resulting dynamics of their implementation, the integration of various knowledge types is of crucial importance. Germany has evolved as a leading advocate for marine conservation, playing an influential role in global conservation efforts. This context provides an interesting opportunity for examining the social and political dynamics of MPA implementation. In this study, we investigate the role of participatory approaches to knowledge integration using the case of two MPAs located in the German exclusive economic zone of the Baltic Sea. To this end, we conducted and analyzed 13 interviews with stakeholders from fisheries, environmental protection, public administration, and science. This approach was complemented by the review of documents leading to the adoption of the management plans. Our research addresses two key questions: (a) How much and what kind of knowledge is included in the management plan of the two German Baltic Sea MPAs and (b) how does this institutional framework promote or hinder the integration of diverse knowledge types? Our findings highlight the obstacles (e.g., power imbalances between different participation levels) of participatory governance levels in the two German MPAs. Thus, this study provides valuable insights for enhancing the effectiveness of participatory governance in German MPAs, thereby advancing marine conservation efforts.

1. Introduction

In response to the growing ocean emergency, marine protected areas (MPAs) have become widely applied tools for conserving and restoring marine ecosystems (Duarte et al., 2020; Gaines et al., 2010; Halpern et al., 2010). MPAs are designated parts of the ocean where human activities are regulated to protect habitats and species (Humphreys & Clark, 2020). Their importance is widely recognized, with MPAs being considered a cornerstone of global marine conservation strategies (Giakoumi et al., 2018). However, they are also criticized for creating imbalances between conservation objectives and societal needs and interests, e.g., in the form of conflicts over access and failures to achieve equitable outcomes underscoring the need for inclusive and adaptive management (Bennett & Dearden, 2014a).

MPAs vary widely in their purposes, management approaches, and regulations, leading to different levels of protection and restrictions on human activities (Day et al., 2012; Horta e Costa et al., 2016; Kriegl et al., 2021). They can range from fully protected marine reserves with strict regulations ("no-take MPAs") to areas that are legally established in policy but lack the management and enforcement to achieve their conservation goals ("paper parks"). Under the right conditions, MPAs have demonstrated significant benefits for species, habitats, and ecological processes (Baskett, 2006; Gaines et al., 2010; Lester et al., 2009).

The success of an MPA primarily depends on its alignment with the unique social-ecological system in which it operates (Fidler et al., 2022; Gaymer et al., 2014; Muhl et al., 2020). Addressing social justice concerns related to MPAs, for example by striving towards an equitable distribution of costs and benefits, is essential for their long-term effectiveness (Bennett et al., 2020; De Santo, 2013; Pike et al., 2024). In this regard, ensuring a fair and diverse representation and inclusion of stakeholders throughout the entire MPA process is key to achieving both ecological and social objectives (Zafra-Calvo et al., 2019). In practice, much of this success hinges on the acceptance, behaviour, and support of local communities (Bennett & Dearden, 2014b; Open Letter to Waldron et al, n.d.). Around the world, inclusive strategies that consider stakeholder engagement and participation have proven critical to achieving successful MPA outcomes (Buxton & Cochrane, 2015). For example, the Great Barrier Reef Marine Park in Australia has seen positive results through its collaborative management approach, involving local communities, traditional owners, and various stakeholders in decision-making processes (Day, 2017). Recognizing this need, the concept of participatory governance has emerged as a promising framework for MPA implementation and management (Di Franco et al., 2020). It emphasizes the inclusion of diverse stakeholders in the decision-making processes, incorporating multiple perspectives, knowledge systems, and values (Bennett, 2018).

Participatory governance strengthens the process of MPA implementation and management by fostering collaboration, transparency, and accountability, thereby reinforcing the sense of ownership and responsibility among stakeholders (Di Franco et al., 2020). Moreover, it can result in sustainable and innovative outcomes, integrating local knowledge and diverse stakeholder perspectives (Newig et al., 2018). However, it also includes pitfalls such as limited stakeholder engagement beyond self-motivated

stakeholders, consultation rather than more inclusive forms of participation, poor timing and trivial or undesirable results for both authorities and/or participants (Dietz & Stern, 2008; Morf et al., 2019). Participative governance frameworks often face significant challenges that limit meaningful stakeholder involvement. For instance, despite aspirations for inclusivity, such frameworks are frequently dominated by established authorities (e.g., governments, scientific councils, and UN organizations in international settings), which restrict the contributions of non-state stakeholders and marginalize diverse perspectives (Esguerra & van der Hel, 2021). These limitations reflect broader critiques that, despite participation aspirations, conventional knowledge systems are often favoured, while sidelining alternative or emerging sources of knowledge (Beck et al., 2017; Sending, 2015). Powerful stakeholders maintain their influence by setting agendas (McCombs, 2005) and excluding options that could redistribute authority, such as granting greater decision-making power to other stakeholders (Esguerra et al., 2017). Unequal representation further exacerbates these issues (Gereke & Brühl, 2019). Additionally, governance institutions prioritize aligning with established audiences, such as scientific committees or political entities, which reinforces the dominance of traditional knowledge bases and limits inclusivity (Esguerra & van der Hel, 2021; Gustafsson & Lidskog, 2017; Haas, 2017). Deliberative democracy as a concept emphasizes equal participation, open dialogue, and collaborative problem-solving (Rosenberg, 2007). However, this ideal form of participation and deliberation might be undermined through previously mentioned pre-existing unequal power dynamics, i.e., power as the possibility for stakeholders to influence and contribute to the decision (e.g., Newig et al., 2018).

The German Baltic Sea, with its extensive MPA coverage and long history of (over)fishing and human impact, provides an interesting case for examining the social and political dynamics of MPA implementation. As MPAs need to balance biodiversity conservation with economic interests (e.g., fishing, tourism, coastal development, or offshore wind projects), while simultaneously addressing critical aspects of the human dimension (e.g., cultural heritage and traditional use, potential displacement and access rights, food security, livelihoods, and the intrinsic value of place), careful consideration of diverse stakeholder objectives and expectations is required (e.g., Bennett & Dearden, 2014b; Cormier-Salem, 2014; Kriegl et al., 2021). An effective governance framework is thus critical to successfully navigate these complex social, ecological, economic, and political realities (e.g., Gaymer et al., 2014; Humphreys & Clark, 2020; McCay & Jones, 2011; Rees et al., 2018), which demands coordination across multiple governance levels. However, after the European Commission initiated an infringement procedure against Germany (infringement number: INFR (2014)2262) the European Court of Justice declared that Germany indeed failed to fulfil the necessary conservation obligations (European Commission, 2021; *European Commission v. Federal Republic of Germany*, 2023). The protected areas declared to be insufficiently protected (i.e., insufficient conservation objectives and no conservation measures) include those examined in this study since deadlines were not met (European Commission, 2020; Figure 1). However, there have been recent efforts for increased protection measures for three MPAs in the Baltic Sea (including our investigated MPAs; European Commission, 2024).

In this article, we explore the role of participatory governance in the establishment of two of the three MPAs in the German Exclusive Economic Zone (EEZ) in the Baltic Sea. In doing so, we illustrate the development process of the management plans of the respective MPAs and address the questions of how much and what type of knowledge is incorporated into these plans as well as how the institutional framework supports or hinders the integration of different knowledge types. In our case, institutional framework refers to the legal (e.g., the Federal Nature Conservation Act), organizational (e.g., one leading agency and different participation levels), and procedural (e.g., first creating a draft of a management plan and then initiating the participation

process) structures that govern the development of management plans of the MPAs. Our findings highlight the challenges of participatory governance in the MPA context, offering practical insights to improve the effectiveness of Germany's MPA network and thereby advancing marine conservation efforts.

2. Material and Methods

2.1. Study Sites

The focus of this study was two MPAs of the German EEZ in the Baltic Sea: Fehmarnbelt and Pomeranian Bay-Rönnebank (Figure 1). Each of these areas allows different uses (e.g., shipping and fishing), which can be restricted in time and space by the implemented management plans (Bundesministerium der Justiz, 2021, 2022). Both MPAs are designated as nature reserves, Natura 2000 areas, and HELCOM MPAs (Bildstein et al., 2020; Bundesamt für Naturschutz [BfN], n.d.-a, n.d.-b; Bundesministerium der Justiz, 2017a, 2017b). The Habitats Directive (Council of the European Communities, 1992) and the Birds Directive (Directive 2009/147/EC, 2010), among others, have declared a wide range of protected goods such as different species (e.g., harbour porpoise [*Phocoena phocoena*]) and habitat structures (e.g., reefs).
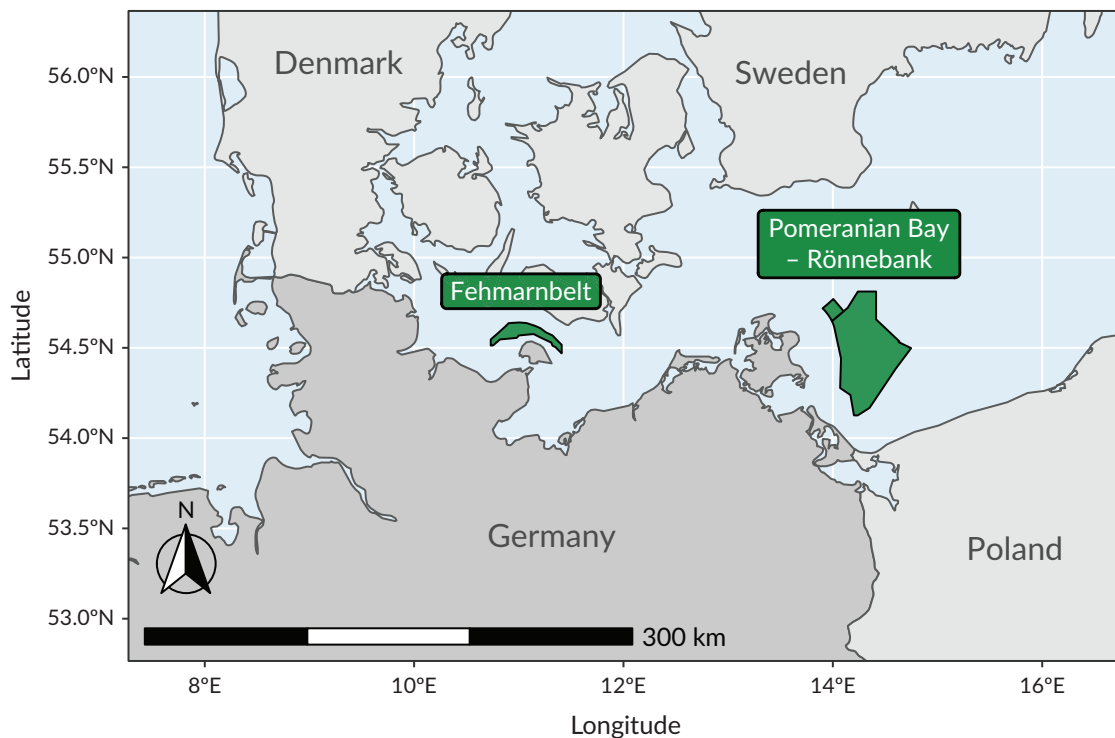
Figure 1. Map of study sites (Fehmarnbelt MPA and Pomeranian Bay-Rönnebank MPA) in the German Baltic Sea EEZ.

The Fehmarnbelt MPA covers 280 km^2 and comprises the protected goods harbour porpoise (Phocoena phocoena), seals (Phoca vitulina), sandbanks, and reefs (Bundesministerium der Justiz, 2017a; Figure 1). The area is mainly used for shipping, commercial fishing, and recreational fishing, with the latter being prohibited by a year-round ban for the western part of the MPA (BfN, n.d.-a; Bundesministerium der Justiz, 2017a).

The Pomeranian Bay–Rönnebank MPA is more than seven times the size of the Fehmarnbelt MPA with an area of 2,092 km^2 and is divided into four areas (Figure 1): Area I: western Rönnebank, Area II: Adlergrund, Area III: Pomeranian Bay with Oderbank, and Area IV: Pomeranian Bay (a special protection area under the Birds Directive, which overlaps in parts with Area II and III; Bundesministerium der Justiz, 2017b). The protected goods include harbour porpoise (Phocoena phocoena), grey seals (Halichoerus grypus), sturgeon (Acipenser oxyrhinchus), twait shad (Alosa fallax), several bird species, sandbanks, and reefs(Bundesministerium der Justiz, 2017b). Fishing (including recreational fishing) is one of the main anthropogenic pressures in these areas (BfN, n.d.-b; Bundesministerium der Justiz, 2017b). In area III (Oderbank), there is a year-round ban on active fishery, i.e., towed gears, in depths < 10 m (BfN, n.d.-b; Council of the European Union, 2005). Moreover, there is a year-round ban on recreational fisheries in the central-eastern part of the MPA (BfN, n.d.-b; Bundesministerium der Justiz, 2017b).

2.2. Data Collection and Analysis

As a first step, we conducted interviews concerning the two German Baltic MPAs, their management as well as the obstacles to their success. A qualitative content analysis was used to identify different categories of barriers to successful MPAs. Since the majority of responses highlighted stakeholder participation as a crucial aspect, we chose to focus on this category in greater depth and conducted follow-up interviews. In a second step, we reconstructed the participation process for the MPA management plan development and identified different participation levels with the combination of stakeholder interview analysis and investigation of official documents. We completed our research by conducting a frequency analysis of submitted statements as part of the development of the MPA management plans for the German Baltic Sea MPAs.

2.2.1. Qualitative Content Analysis of Stakeholder Interviews

To explore and understand the different perceptions and knowledge types regarding the German Baltic MPAs in general, and more specifically, the barriers to their success (e.g., power imbalance between different participation levels), we conducted 10 semi-structured interviews with relevant stakeholders from public administration ($n = 1$), commercial fisheries ($n = 2$), environmental non-governmental organization (eNGO; $n = 2$), recreational fisheries ($n = 2$), and science ($n = 3$; Supplementary File, Table A1). The interview guide used for this purpose contained a total of 18 questions (Supplementary File, Table A2). All interviews were voice-recorded and conducted either in person or online.

Interviews allow for a more in-depth exploration of complex issues, providing flexibility to probe further into responses and capture nuanced perspectives that might be missed in structured surveys. This method is particularly suitable for understanding diverse knowledge types in MPA management. Previous studies on MPAs have effectively used interviews to gather rich, qualitative data. For instance, Voyer et al. (2014) employed semi-structured interviews to examine social acceptance of MPAs in Australia revealing complex socio-cultural factors influencing stakeholder perceptions. Similarly, Jentoft et al. (2012) used interviews to examine stakeholder perceptions of MPAs in Spain. This study builds on these approaches by specifically focusing on knowledge integration in the German Baltic context. By doing so, it contributes to a more nuanced understanding of the challenges and opportunities in MPA governance, particularly concerning stakeholder engagement.

We conducted an inductive data analysis by screening and coding the interview data as well as by performing a sequence-based content and thematic analysis (Dawson, 2009; Gläser & Laudel, 2010). Two interviews were selected at random from which we developed initial categories for the analysis. From this process, a total of five analytical categories were developed, further divided into different subcategories: (a) management, (b) management plan, (c) management measures, (d) stakeholder participation, and (e) anthropogenic pressures on MPAs (Supplementary File, Table A3).

Based on the highest number of mentions within all interviews, we focus further on the category stakeholder participation and associated subcategories. To gain a deeper understanding in this regard, three additional interviews were conducted with stakeholders representing a sample of the 10 stakeholders from the first interview series (public administration, science, and eNGO; Supplementary File, Table A4). The 11 questions focused on stakeholders' knowledge about participation and the way stakeholder participation was designed and applied in the German Baltic MPAs (Supplementary File, Table A5).

2.2.2. Document Review

To identify different participation levels and reconstruct the management plan development process, we conducted a review of relevant documents. Those include, for example, The Act on Nature Conservation and Landscape Management, the ordinances, the management plans, the website of the Federal Agency for Nature Conservation (BfN) and an available lecture on law as well as a law template focusing on (participation) procedures (Bildstein et al., 2020; BfN, n.d.-c; Bundesministerium der Justiz, 2009, 2017a, 2017b, 2021, 2022; Heintzen, 2003; Juraforum, 2024).

2.2.3. Frequency Analysis of Stakeholder Statements

We were provided with a list summarizing the written statements submitted on the MPAs. According to this list, 42 statements were submitted between June 2020 and the third of September 2020 by various stakeholder groups including public administration, commercial fisheries, politics, and eNGOs (e.g., Bundesministerium der Justiz, 2021, 2022). Regarding the knowledge integration into the management plans, this list was analyzed by categorizing the statements into different stakeholder groups (public administration, science, fisheries, recreation, eNGOs, tourism, and industry) and by different governance levels (local, i.e., municipal, regional, i.e., state [*Bundesland*], national, i.e., federal, and international). Subsequently, the percentage contribution of each stakeholder group to the total number of statements was calculated. The stakeholder group of public administration include, for example, state offices and ministries with different focus areas from all defined governance levels.

3. Results

This section starts by illustrating the participation process for the management plan development; first, by introducing the three participation levels within the process and second, by reconstructing the process. The basis for both is mainly the document review, however additional insights from stakeholder interviews (especially from public administration) helped to better understand and reconstruct the process. Afterwards, the section continues with the results from the frequency analysis of the submitted written statements that formed the basis to answer the research question regarding knowledge type integration. This basis

(participation levels, process, and knowledge integration) as well as insights from the interviews were used to then answer the second research question regarding the institutional framework at the end of this section. When information is based on an interview conducted, the stakeholder group will be shown in italics as in brackets, e.g., (*science*) at the end of the quote.

In Germany, the legal framework mandates stakeholder participation in the MPA planning process (Bundesministerium der Justiz, 2009, 2017a, 2017b). As such, the development of management plans for the German Baltic Sea MPAs followed a structured hierarchy of participation, divided into three levels: agreement, consultation, and involvement (Figure 2). The agreement level, which includes national authorities with veto rights, represents the highest concentration of power, while the involvement level, encompassing the interested public and associations, had the least power. The participation process itself was divided into two phases: the first focused on the ordinances of the MPAs, and the second centred on gathering feedback on the draft management plans. Each phase began with an initial involvement stage, followed by consultation and agreement (Figure 3).

3.1. Hierarchical Order of Power and Influence

The development of and decision on appropriate measures follows a hierarchical order provided by The Act on Nature Conservation and Landscape Management (Bundesministerium der Justiz, 2009), which is also integrated into the corresponding ordinance of the respective MPAs (Bundesministerium der Justiz, 2017a, 2017b; Figure 2).
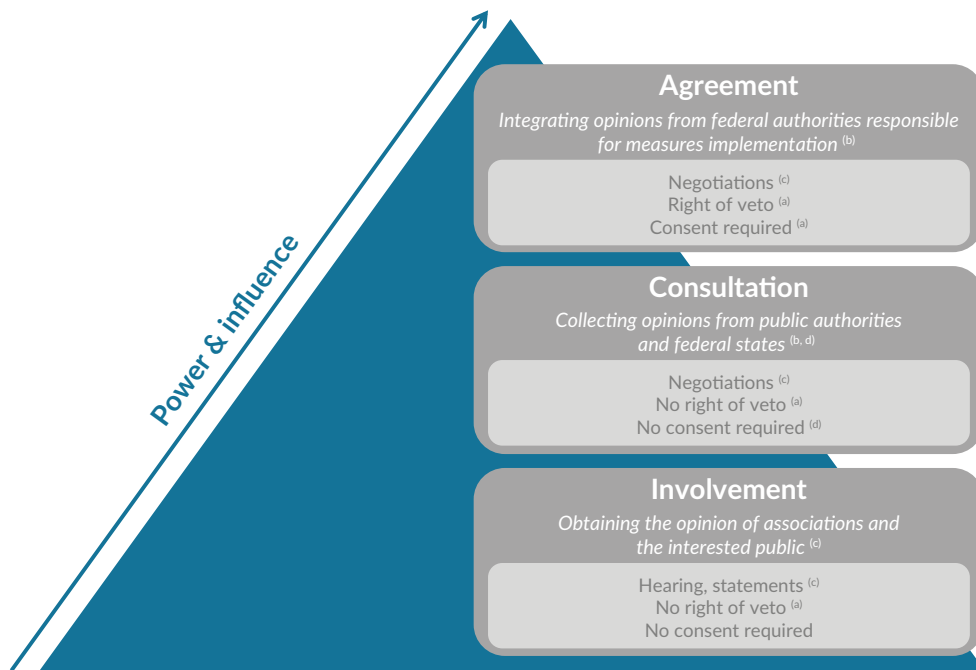
Figure 2. The hierarchical order of power and influence in the various participation forms and associated involved parties in the process of MPA management plan development in the German EEZ. Notes: (a) Bundesministerium der Justiz (1976, § 58); Heintzen (2003); (b) Bundesministerium der Justiz (2009, §57–§58, and §63; 2017a, §7; 2017b, §11); (c) Interviews; (d) Juraforum (2024); (e) "Rechtswissenschaft: Benehmen und Einvernehmen" (2017).

The BfN is the competent authority for the development of management plans for MPAs in the EEZ. The act and ordinances require an agreement between BfN and other federal agencies, such as the Federal Ministry for Digital and Transport, the Federal Ministry of Food and Agriculture, or the Federal Maritime and Hydrographic Agency, that are responsible for the execution of the measures (Bundesministerium der Justiz, 2017a, §7; 2017b, §11). Consent is required and these stakeholders have a right of veto resembling the highest form of power or influence in the decision-making process (Bundesministerium der Justiz, 1976, §58; Heintzen, 2003). A consultation is needed with the neighboring federal states, i.e., countries (e.g., Denmark) and the relevant public agencies, i.e., not directly responsible for implementation or from the respective coastal state (*Bundesland*; Bundesministerium der Justiz, 2009, §57–§58). These stakeholders resemble intermediate power or influence on the decision-making process, since they do not have a right of veto and no consent is required (Heintzen, 2003; Juraforum, 2024). However, consultation is considered as a higher form of participation than involvement, occurring through negotiations ("Rechtswissenschaft: Benehmen und Einvernehmen," 2017). The interested public and federally acknowledged associations (Bundesministerium der Justiz, 2009, § 63, Section 1) are integrated through involvement, i.e., the participation form with the lowest influence or power on the decision-making process. Stakeholders can communicate their opinions and must be heard, yet implementation of their opinions into the management is not legally required and depends on the authority leading the process (Heintzen, 2003):

> We have the opportunity to write statements…and we have been heard in hearings, so to speak. Whether that had a significant influence on what ultimately came about is a question I'll leave open. But I can say that I don't have the feeling that we have a major influence on it. (*eNGO*)
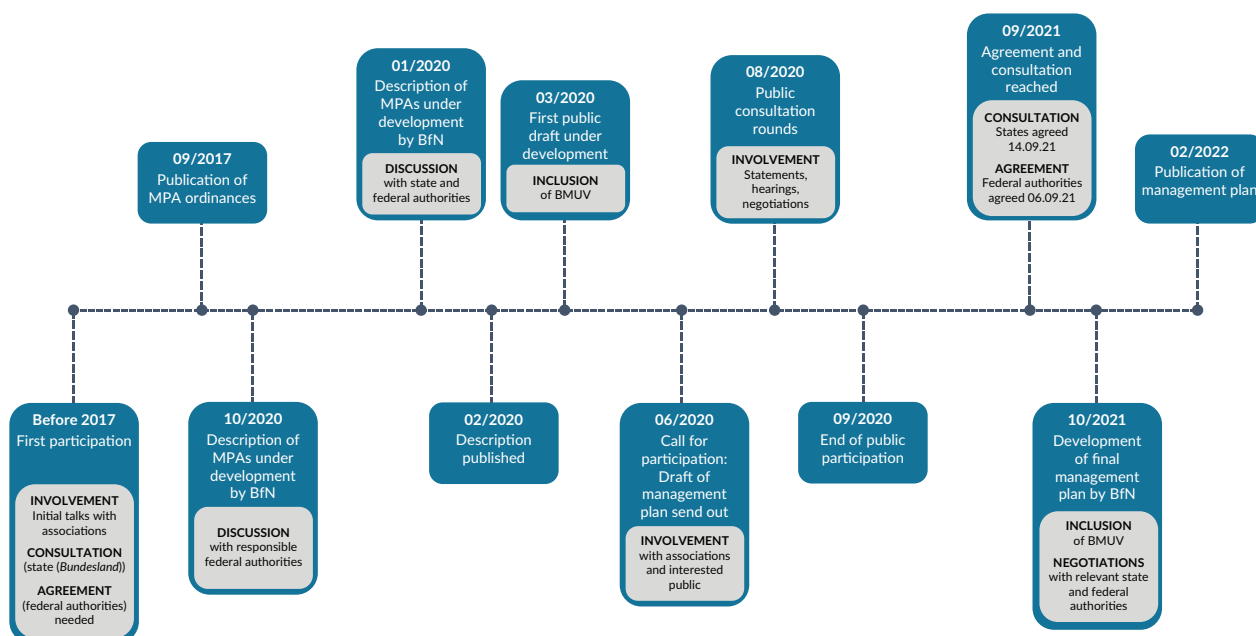
Figure 3. Chronological order of phases in the process of management plan development of the two MPAs (Fehmarnbelt and Pomeranian Bay-Rönnebank) including time frame, description, and identified forms of participation. Notes: BMUV = Bundesministerium für Umwelt, Naturschutz, nukleare Sicherheit und Verbraucherschutz (Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection); BfN (Federal Agency for Nature Conservation); This figure is based on the following literature: Bildstein et al. (2020), BfN (n.d.-c), Bundesministerium der Justiz (2021, 2022), and interviews.

To understand the proceedings, we have visualized the process of management plan development of the two MPAs focusing on participation (Figure 3): Already before 2017, the public was first included through the involvement of relevant stakeholders, such as anglers and fisheries associations, as well as the requirement for the agreement of relevant federal agencies to develop protected area ordinances (*public administration*). In 2017, the ordinances were published, designating the areas as nature reserves under German law. However, most management measures and restrictions are addressed in the management plans. The development of those was initiated in 2020 by BfN, which provided a description of the suggested protected area (Bildstein et al., 2020). This description was discussed with the federal (national) and state (*Bundesland*) authorities. The hereafter coordinated first management plan draft was published in February 2020 (BfN, n.d.-c) and formed the foundation for the management plan. After this, the BfN redrafted the management plan by including the superordinate ministry (i.e., BMUV). By the summer of 2020, the latest draft was published to enable the involvement of public authorities and the broader public. In two public hearings and a subsequent option to submit written statements, the aforementioned stakeholders could express their concerns and comment on the drafted management plan (Bundesministerium der Justiz, 2021, 2022). In total, 42 statements were handed in (see Section 2.2.3). Statements and comments were evaluated individually by BfN. Finally, there were negotiations with the authorities responsible for implementing the measures, but in different stakeholder constellations (*science*). Those negotiations aimed to obtain agreement and consultation as it is a legal requirement for the management plan to become effective. Agreement and consultation were obtained in September 2021 (Bundesministerium der Justiz, 2021, 2022). In early 2022, the final management plans were officially published and thus entered into force.

While we focus only on the activities leading up to the approval of the management plans, it is important to note that the plans themselves include participatory measures, e.g., the establishment of round tables with commercial fisheries (M6.2 in managementplan for Fehmarnbelt MPA; Bundesministerium der Justiz, 2021).

3.2. How Much and What Kind of Knowledge Was Integrated Into the Management Plans?

We define knowledge as a collective term for multiple knowledge types that arise in various ways—though personal experiences, jobs, tradition, norms and values, but also through the interaction with a social-ecological system including observation and spatial operation (Schwermer et al., 2021). Examples include fishers' ecological knowledge (i.e., the knowledge that fishers generate through interaction with the sea) or traditional knowledge (i.e., knowledge that is passed down through generations within communities; Folke, 2004).

The analysis of the 42 submitted statements of the involvement phase indicated that perspectives and knowledge types of public administration stakeholders are most frequently incorporated in the management plans (47.6%; Figure 4). The second largest stakeholder group represented is recreation (14.3%), followed by eNGOs (11.9%) as the third largest stakeholder group. Industry (9.5%), tourism (7.1%), fisheries (7.1%), and science (2.4%) each accounted for less than 10% of the statements submitted.

Regarding the governance level, most statements (59.5%) have been submitted by stakeholders from the national level, the highest governance level within Germany, followed by the regional (33.3%), local (4.8%), and international level (2.4%; Figure 5).
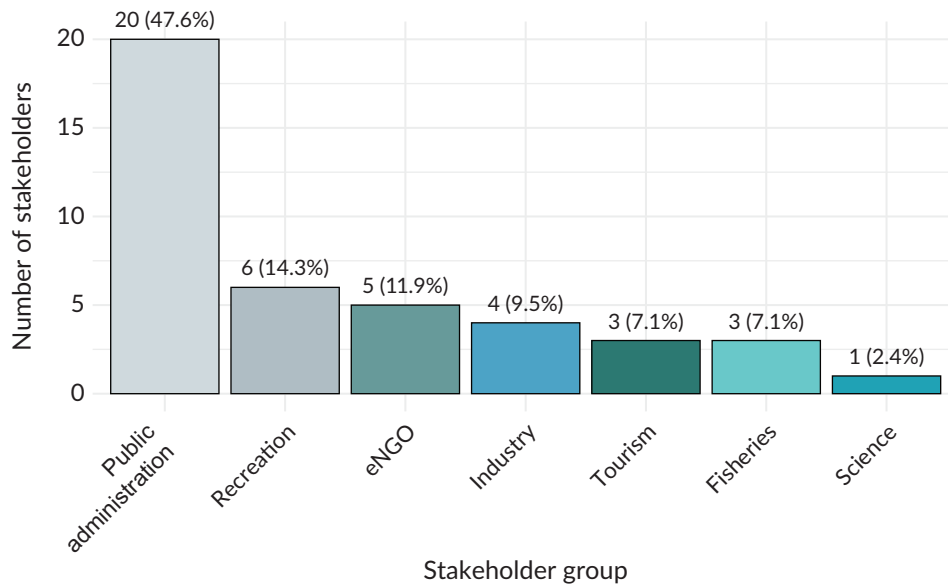
Figure 4. Bar chart displaying the total number of submitted statements in the involvement phase by each stakeholder group.
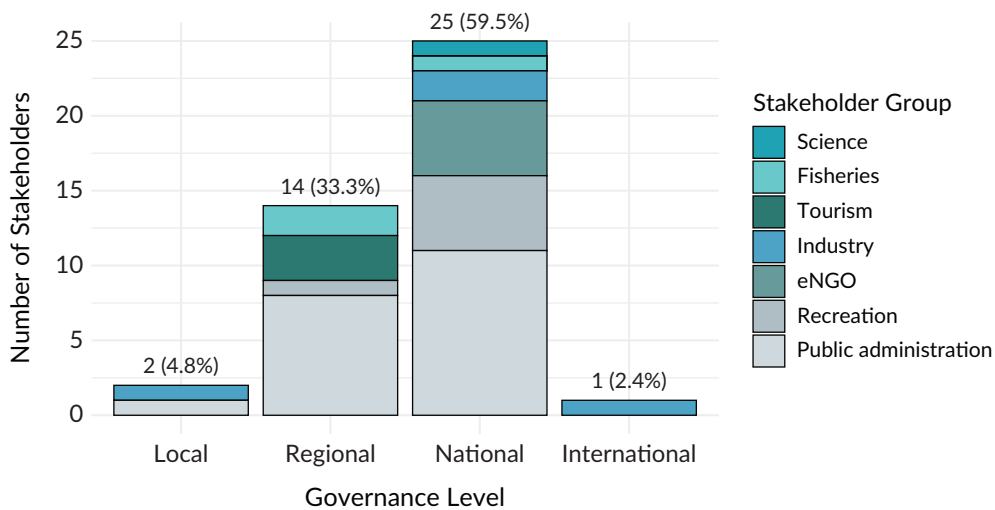
Figure 5. Sectoral representation of the 42 submitted stakeholder statements in the involvement phase across governance levels. Note: The stacked bar chart displays the distribution of stakeholder groups across different governance levels: local, regional, national, and international.

3.3. How Does the Institutional Framework Support or Hinder the Integration of Different Knowledge Types?

Analyzing the interviews generally revealed that the process of developing MPA management plans is perceived and described as top-down:

> Ultimately, this is a top-down approach. It is not the case, that all stakeholders are involved in the process. (*eNGO*)

However, a key aim of the legally mandated participation process is the integration of diverse knowledge types, whereby the integration of public authorities from different fields of specification is mandatory. Therefore, a bias towards this knowledge type was observed, even though their viewpoints differ according to the field of specification, especially noticeable at the agreement level where consensus is required.

Moreover, interviews indicated that the authority leading the process strongly preferred scientific knowledge when drafting the management plans (*science*). Despite only one formal submission from the scientific community, the plans were significantly informed by informal consultations with scientists:

> It was precisely these plans that were deliberately written to be science-based. That was…simply an important concern for BfN. And [in] this production process, not only were papers read, of course, but we also repeatedly spoke to scientists who were familiar with these areas, but that was also more informal, i.e., not that an appointment was scheduled. (*science*)

Non-scientific knowledge, such as local ecological knowledge (e.g., knowledge of environments that accumulate while operating in resource use activities; Hind, 2014) or traditional knowledge (Folke, 2004) faced challenges in being integrated unless supported by concrete data or evidence, like scientific publications (*public administration*). While the involvement phase did help to identify and incorporate some stakeholder interests, the integration of different knowledge types was further complicated by diverging statements from various stakeholders:

> At the same time, however, and this is prescribed by the EU Habitats Directive, meaning that if the establishment of protected areas is of no use for highly migratory species in particular, measures must be taken in these areas to protect the species. And that brings us to the use of pingers. And at this point, there can be indeed a real socio-political conflict between our views and that of the BfN, where we say that such pingers can also be used in protected areas and the BfN says no, as the animals are to be left alone in these areas. (*science*)

4. Discussion

A majority of statements during the involvement phase concerning the draft management plans have been submitted by administrative stakeholders, predominantly from the national level. Although a detailed analysis of the degree of consideration of these submissions was not possible due to limited access, the high proportion of statements from administrative stakeholders implies a dominant influence on the creation of management plans. The predominance of national-level submissions likely reflects the fact that these MPAs are located in Germany's EEZ, placing them under national authority. This, combined with the greater power of national authorities and involvement at all three participation levels, likely fostered a primarily administrative and political discourse about these MPAs, potentially marginalizing other perspectives. Even though at the involvement level, there is a legal obligation to acknowledge all statements received during public participation, there is no obligation to integrate them. If, for example, an association was not officially listed to be contacted or did not regularly visit the authority's website, it might have missed the call for participation. This highlights that the way how the broader public is addressed is limiting its reach to a smaller group of highly interested public, such as people or groups who feel directly related or impacted. Hence, despite legally mandated stakeholder participation, their influence is limited. Similar challenges can

be observed in other cases, such as at the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) and Future Earth, where the design of participation frameworks constrains the involvement of diverse stakeholders (Esguerra & van der Hel, 2021). Even though these platforms aim for inclusivity, decision-making power remains concentrated in the hands of established authorities—such as governments, scientific councils, and UN organizations—which restricts the ability of non-state stakeholders to influence decisions and limits the integration of new perspectives and various knowledge types. In our case, the initial drafting of management plans by the BfN focuses heavily on scientific knowledge (potentially limiting the integration of other perspectives and knowledge types later in the process), while the consensus finding then takes place in the political area (agreement phase and highest degree of power). A key strength of the current system from our case is its emphasis on achieving consensus at the agreement level, where decisions must be unanimous rather than based on majority votes. On one hand, this requirement ensures that all involved authorities are committed to enforcing the measures they agree upon, fostering greater acceptance of the final decisions. On the other hand, this approach leads to fewer agreements, as reaching a unanimous consensus can be challenging.

As the institutional framework and participation structure for the German Baltic Sea MPAs favoured the integration of administrative and scientific knowledge, particularly from national authorities, this may have limited the inclusion of more diverse perspectives, particularly those arising from the involvement level, thereby complicating the process of developing comprehensive management plans. Most contributions supported by evidence, such as data or scientific publications, were brought to the next level of participation. However, the emphasis on conventional knowledge hinders the inclusion of more diverse or alternative perspectives. A reason for this could be that participatory ambitions can create tensions between conventional and new foundations and sources of knowledge (Haas, 2017). Thus, institutional designs and frameworks influence what kind of knowledge is considered legitimate and integrated into decision-making processes (Esguerra & van der Hel, 2021). Our cases reflect this and what is also occurring in broader contexts like with IPBES, indicating that the institutional frameworks support rather scientific knowledge and consensus as the dominant foundations for decision-making (Beck et al., 2017; Sending, 2015). Furthermore, other knowledge types such as local ecological knowledge or non-scientific expertise, are typically introduced through written statements during the involvement phase, which (a) holds the least influence and (b) is a rather formal way that could imply some hierarchy. Despite favouring the integration of scientific knowledge, science was the least involved stakeholder group. This incongruity can be traced back to the involvement of scientific articles by the public administration, by consulting scientists from different relevant scientific fields in an indirect way. Therefore, it is more advisable to rather employ an independent scientific advisory board with scientists from all relevant disciplines, as was the case with the public participation process in the German marine spatial planning processes, instead of limiting scientific advice to selected scientific articles and scientists (Bundesanzeiger Verlag, 2021; Kannen, 2021).

The drive for embeddedness into existing administrative and scientific contexts is rooted in desired recognition. Esguerra and van der Hel (2021) demonstrate how the resulting institutional decisions depend on the interactions with different audiences from which knowledge platforms or institutions pursue recognition (e.g., scientific committees and certain administrative/political stakeholders; Gustafsson & Lidskog, 2017; Sending, 2017). This is applicable in our case, where broad acceptance and recognition of the management plans are sought.

Additionally, the varying personnel strength among different administrative and political authorities, especially during the agreement phase, might have created an imbalance within this group, affecting the likelihood of certain topics and measures being included: "Although [these MPAs are] the area of competence of the environment department, they were significantly weaker in terms of personnel...than some other authorities" (*science*).

Since the environmental stance of participating stakeholders was identified as an important predictor for environmental governance outcomes (Newig et al., 2023), this becomes especially important for MPAs that are designed for conservation: The environmental priorities and interests of participating stakeholders will be evident in the decisions made (Newig et al., 2023). Ultimately, MPAs may be legally bound to administrative borders, but their effectiveness can only be ensured when established according to their natural functioning. Therefore, the consideration of adjacent marine areas, i.e., responsible regional and international authorities, is crucial for the success of an MPA. Cross-border communication with respective regional and international authorities makes public participation a tool to improve marine spatial planning (García-Sanabria et al., 2021) and potentially also MPAs.

In our study, the institutional framework and power disproportions emerged as critical barriers to meaningful participation. While Esguerra et al. (2017) argue that powerful stakeholders with decision-making power maintain control over decision-making by excluding options that could induce power shifts (e.g., granting other stakeholders voting rights) from the agenda of negotiations, Gereke and Brühl (2019) highlight the unequal representation. On the international scene of political agenda-setting, there is an over-representation of NGOs from the Global North in comparison to NGOs from the Global South, leading to a disproportionate representation of different perspectives (Gereke & Brühl, 2019). Scaling this argument down to our case, unequal representation was observed in the involvement phase, mainly with administrative statements and particularly at the agreement level amongst ministries. Disproportionately weighted decisions according to who is at the table are the undesired results, i.e., some stakeholders, including those from eNGOs and administrative bodies, have expressed concerns that the process lacks balance, because economic interests are often prioritized over nature conservation. Ensuring equal parity among ministries has been suggested as a potential solution in the interviews. Similarly, hierarchies between different levels of participation can create additional power disproportions. Through this hierarchical structure, power—as the possibility for stakeholders to influence and contribute to the decision (Newig et al., 2018)—lies with ministries at the agreement level and not with the stakeholders in the involvement phase, which reinforces existing power imbalances. It has been shown that participation improves environmental governance outputs (Newig et al., 2023). Thus, in the context of MPAs, where environmental protection is the core objective, the role of participation becomes even more critical.

While the legal obligation for participation theoretically promotes a wide knowledge integration, the hierarchical structure of the participation process favours political and administrative stakeholders, particularly at the agreement level. Such a static institutional framework hinders the incorporation of more diverse knowledge types. Especially those perspectives from the involvement phase represent the broader range of knowledge types, which should be integrated further up the participation process if the latter is aimed to be a bottom-up and just process. This observation is consistent with other cases in which participation was anticipated and addressed through participatory norms, but (a) only served to establish "legitimacy" and (b) remained limited in scope and relevance (Connelly et al., 2006; Esguerra et al., 2017; Turnhout et al., 2015).

The empirical insights from our case reflect broader patterns that can also be observed across a wide range of platforms, including IPBES, Future Earth, and international climate change negotiations (Esguerra et al., 2017; Esguerra & van der Hel, 2021; Gereke & Brühl, 2019). Institutional constraints (e.g., the legally pre-defined hierarchical structure of participation), power asymmetries, limited staff to exercise participation, and limited participation (e.g., due to disinterest and non-involvement) continue to hinder the integration of diverse knowledge types into decision-making processes. This also becomes important as organizations and institutions are increasingly judged not only by their effectiveness in delivering results but also by how transparent, fair, and inclusive they are in decision-making processes (Tallberg & Zürn, 2019). Failure to embrace inclusivity may thus erode their legitimacy.

4.1. Recommendations for Improvement

Based on the findings of our study, we propose six key recommendations to enhance stakeholder participation and the integration of diverse knowledge types in MPA establishment processes.

Beyond formal instruments of public participation: implement a broader range of participation tools (besides written statements and formal hearings), such as stakeholder meetings, online surveys, multi-sector forums, post-meeting feedback, and regional panels (Buxton & Cochrane, 2015; Kannen, 2014). Additionally, introducing less formal and more interactive methods could encourage broader public involvement. Efforts should be directed towards ensuring equal representation of various stakeholder groups. Challenges, such as reconciling contradictory perspectives and integrating different knowledge types (e.g., Schwermer et al., 2021), can be mitigated by employing neutral moderators. These moderators, accepted by all stakeholders, can foster more effective collaboration and enhance concensus, ultimately improving the acceptance of management measures.

Accepted methodologies: establishing and adhering to universally accepted definitions and methodologies to establish baseline data as well as incorporating unconventional data sources (Buxton & Cochrane, 2015) could enhance collaboration and trust among stakeholders. Anticipated outcomes of the MPA process should be continuously and transparently discussed with involved and affected stakeholders and communities (Buxton & Cochrane, 2015). In the case of fisheries, involving stakeholders in data collection and/or improving communication about methodologies and findings could further enhance participation and support of, e.g., management measures (de Graaf et al., 2023).

Revised involvement phase: obtain input from stakeholders during the involvement phase before and after the publication of the draft management plan. This approach used effectively in the Australian MPA process, could lead to better integration of stakeholder knowledge and greater acceptance of the final plan (Buxton & Cochrane, 2015). Currently, the German process invites public input only after the draft is published, limiting early influence. A successful example of early stakeholder integration is the Boddenpike project (https://www.igb-berlin.de/en/project/boddenpike), where fisheries scientists and various stakeholders collaborated to better understand and manage the fishery use of pike in lagoons in Germany. As a result: a list of collaboratively developed and agreed management measures for the protection and harvesting of this species has been submitted to the responsible ministry (Ehrlich et al., 2023). Adopting similar early engagement strategies in MPA processes could lead to stronger, more inclusive management plans.

Committees for social, economic, and cultural impacts: establishing dedicated committees focused on the social, economic, and cultural impacts of MPAs, similar to the Great Barrier Reef Marine Park (Thompson et al., 2004). These committees could, e.g., aim at minimizing impacts on existing users as far as possible (Thompson et al., 2004). This is in line with literature calling for not only assessing environmental, but also potential socio-economic impacts (Goti-Aralucea, 2019) and considering the "triple bottom line" (of economy, environment, and society) in MPA planning and implementation (Rees et al., 2018). Moreover, investigating knowledge types and perceptions of various stakeholders might be a first step to overcoming issues regarding stakeholder participation and thus lead to a successful MPA (Dimech et al., 2009; Pita et al., 2011; Schwermer et. al., 2021).

Multiple protection options: offering multiple options for achieving protection goals, rather than presenting a single draft plan. Providing alternative paths to reaching the desired outcomes could encourage broader stakeholder involvement. Thinking about and testing divergent protection concepts (e.g., no-take areas, multi-use; Przedrzymirska et al., 2021) could also increase the acceptance of measures. However, appropriate monitoring protocols and a clear time frame should be defined in advance. Co-management arrangements, where stakeholders share management responsibilities, could provide an ideal framework for considering and implementing different protection options (Di Franco et al., 2020).

Scientific advisory board: appoint an advisory board with scientists of relevant disciplines (e.g., marine biology, geography, and sociology) to promote the inclusion of diverse scientific knowledge in the participation process and ensure an independent scientific assessment (e.g., Bundesanzeiger Verlag, 2021; eMSP NBSR, n.d.; Kannen, 2021; National Oceanic and Atmospheric Administration, n.d.).

5. Conclusion

Stakeholder knowledge integration ranges from providing information for research and management (Stephenson et al., 2016) to active participation of stakeholders in research and/or governance following a transdisciplinary approach (Grünhagen et al., 2022). However, integration requires more than just participation: it demands legally binding inclusion in, for example, decision-making processes (Stepanova, 2019). While legal obligations for participation may exist (as in the case of the German Baltic Sea MPAs), they do not guarantee the integration of stakeholders' knowledge which may cause conflicts such as the lack of acceptance of management measures and trust (Stepanova, 2019). Our study highlights this issue, with unequal power distribution allowing dominant stakeholders to influence decisions (Flyvbjerg, 1998). To ensure fair outcomes, balancing power through equal representation and legally mandated stakeholder involvement is crucial for successful MPAs (Busch et al., 2010; Stepanova, 2019).

In this regard, attributes of deliberative democracy become important: The theoretical framework of deliberative democracy highlights the value of equal participation and open dialogue in decision-making processes (Rosenberg, 2007). This collaborative approach is characterized by clarification, elaboration, and revision of common conceptions and values when addressing specific problems thus offering a framework to address the mentioned shortcomings (Rosenberg, 2007).

The development of management plans for the two German Baltic Sea MPAs underscores the complexities of stakeholder participation within a legally mandated, hierarchical framework. This framework, divided into

three levels—agreement, consultation, and involvement—reveals a structure where the most power resides at the agreement level, dominated by administrative stakeholders with veto rights. While this ensures that consensus is necessary for decision-making, it also limits the integration of more diverse knowledge types, particularly those from stakeholders at the involvement level.

Our findings indicate that the majority of contributions were submitted by representatives from public administration particularly at the national level, indicating that the management plans were probably strongly influenced by these perspectives and knowledge types. To enhance the integration of multiple perspectives and knowledge types, as well as to achieve a more balanced and effective management plan, the participation process could benefit from several key improvements: (a) broader and more inclusive participation tools, (b) earlier stakeholder engagement, and (c) stronger emphasis on social and economic considerations. Ensuring that all relevant stakeholders have a voice in the process, supported by legal frameworks that require their input to be genuinely considered, is essential for overcoming the current imbalances. Without this, the process risks being dominated by a narrow set of interests, potentially undermining the broader goals of conservation and sustainable use.

Future research should focus on the scientific evaluation of the management plan implementation and its efficiency not least in order to discuss and establish adaptative management concepts using various participatory tools. This also includes the introduction of no-take-areas whose monitoring and evaluation in a transdisciplinary approach could increase the acceptance of this most discussed management measure across various stakeholder groups. The sustainability transformation in the German Baltic Sea could thus be advanced using the example of MPAs.

Conflict of Interests
The authors declare no conflict of interests.

Data Availability
The data presented in this study are available on request from the corresponding author. The data are not publicly available due to restrictions, i.e., privacy and ethics.

Supplementary Material

Supplementary material for this article is available online in the format provided by the author (unedited).

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Cogitatio

A Heuristic for Integrating Sense of Place Into Ocean Governance

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Abstract

Sense of place (SoP) is a powerful yet underutilised social value with significant potential to improve collaboration and inclusivity in ocean governance. Recent evidence, however, has shown that a range of barriers prevent the routine integration of SoP in this space. To help overcome this, this commentary proposes a preliminary heuristic—or rules of thumb—that can help guide researchers and practitioners to help them incorporate SoP into ocean governance. The heuristic emphasizes fostering collaboration, inclusivity, and shared understanding among diverse stakeholders and non-academic actors. It advocates for the co-production of knowledge across disciplines and institutions, iterative reflexivity to address positionality, and the creation of shared definitions and measures of SoP tailored to specific contexts. It explores balancing a broad conceptual understanding of SoP with localized tangible applications to ensure relevance and impact. Celebrating "bright spots," or successful instances where research has informed policy, is also highlighted as a way to inspire and support the utilization of SoP in management decisions. By utilizing SoP as a relational tool, we posit that ocean governance practitioners can enhance trust, promote more meaningful stakeholder engagement, and align diverse perspectives toward common goals, thus building more inclusive and collaborative management practices.

Keywords

marine management; ocean governance; sense of place; social values; stakeholder collaboration

1. Introduction

Humanity is exerting more pressure on the planet than ever before (Steffen et al., 2007), and these pressures are pushing planetary boundaries beyond a safe operating space (Nash et al., 2022; Steffen et al., 2007).

Marine systems in particular are facing significant threats, with warming oceans, the spread of invasive species, overfishing, and myriad more pressures, all of which have cumulative impacts (Nash et al., 2022). These impacts do not exist in isolation; they are deeply intertwined and interact as part of broader social-ecological systems, that is, the "integrated system(s) of ecosystems and human society with reciprocal feedback and interdependence" (Folke et al., 2010, p. 3). These interlinkages mean that successfully navigating these challenges requires the integration of diverse social values, knowledge systems, and voices to make governance processes more inclusive and collaborative, ultimately leading to their success (N. J. Bennett et al., 2017).

One phenomenon that is gaining increased attention in the literature is the sense of place (SoP). Broadly defined as the emotional bond that an individual or group has with a place (van Putten et al., 2018). SoP incorporates and encompasses other related concepts such as place attachment, dependence, and identity (Masterson et al., 2017; Stedman, 2002) and place meaning (Farnum et al., 2005; Raymond et al., 2017). Each of these components is largely interrelated and interconnected, varying in importance depending on the context and discipline within which they are explored (Farnum et al., 2005; Jorgensen & Stedman, 2001; Stedman & Beckley, 2007; Williams & Patterson, 2007). However, for our research, they all fall, at least in part, under the general concept of SoP (Jorgensen & Stedman, 2001; Trentelman, 2009). For this commentary, we adopt the definition of Hausmann et al. (2016, p. 117) that states: "[SoP] embeds all dimensions of peoples' perceptions and interpretations of the environment, such as attachment, identity or symbolic meaning, and has the potential to link social and ecological issues." This link to social and ecological issues positions SoP as a prime candidate for consideration and inclusion in the governance of social-ecological systems, being both a driver and an outcome of social-ecological processes (Masterson et al., 2017).

SoP has been shown to be an indicator of community resilience against disruption (Faulkner et al., 2018) and can be a powerful motivating force for adaptation. It can also be an indicator of pro-environmental behaviour (Alonso-Vazquez et al., 2018). and has been shown to have links to physical and psychological well-being (Hausmann et al., 2016; Scannell & Gifford, 2017). Additionally, SoP can also be a tool for collaboration; building social cohesion between stakeholders with shared SoP (Enqvist et al., 2017; Rodríguez-Morales et al., 2020). For a comprehensive overview of SoP see Raymond et al. (2021).

Ocean governance in particular is an area where recent research has shown both researchers and decision-makers see relevance and value for SoP (Duggan et al., 2024a; van Putten et al., 2018). However, there remain limited examples of its effective inclusion into decision-making processes (Duggan et al., 2023b). This is largely driven by a range of structural and institutional barriers (Duggan et al., 2023a), alongside challenges in effectively articulating a phenomenon that can be simultaneously tangible and abstract (Duggan et al., 2023b, 2024a) and perceived barriers in crossing the interface between science and policy (Duggan et al., 2024b). As such, it seems timely to work with and better support decision-makers to incorporate SoP into their decision-making processes to make them more inclusive and collaborative.

To this end, in this commentary, the authors reflect on their cumulative experience of over 50 years in research and practice at the science-policy interface (with much of this in the marine space, via a combination of academic research, environmental impact assessments, and reserve management) to identify a heuristic—or rules of thumb—for incorporating SoP into decision-making for improved ocean governance.

In terms of an SoP focus, this heuristic builds on the work of Raymond et al. (2021), acknowledging the complexities and diverse conceptualisations of SoP, and is informed by and builds on research into the conceptualisation, measurement, application, and articulation of the phenomenon (Duggan et al., 2023a, 2023b, 2024a, 2024b; Duggan & Sokini, 2021). This heuristic (Figure 1) is not intended to be a comprehensive conceptual framework, but rather a selection of practical considerations and tools based on experiential knowledge and research, presented as a jumping-off point for further conversation and research.
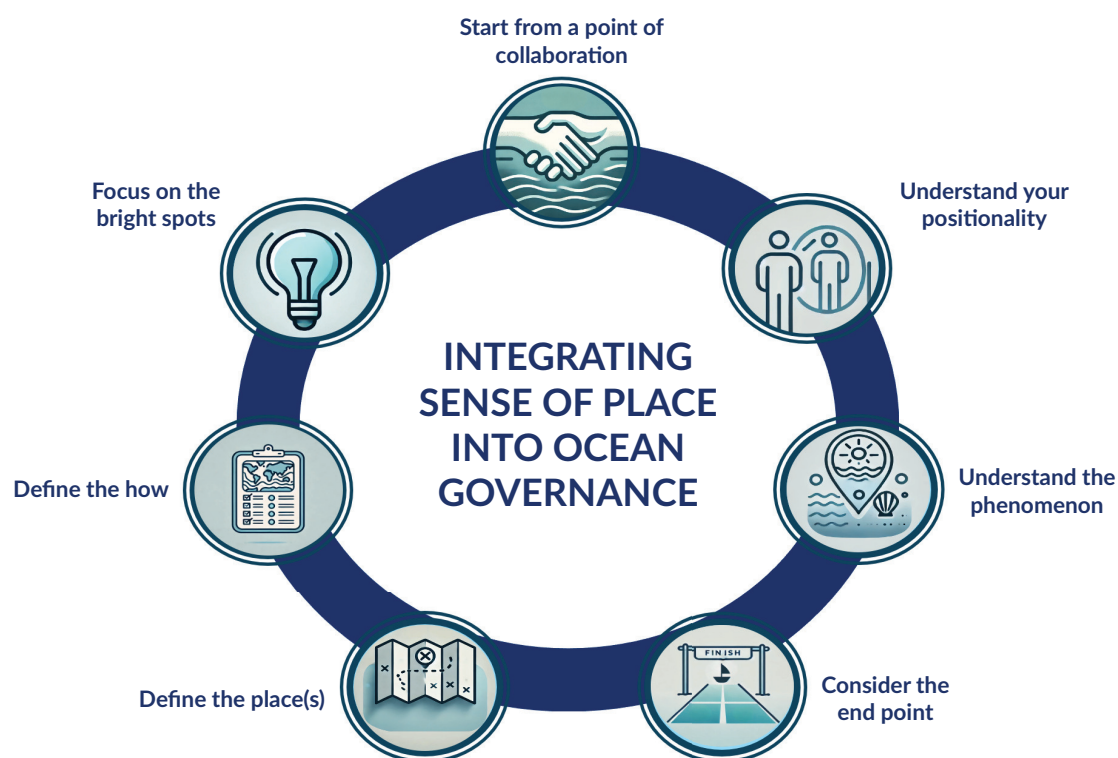
Figure 1. Visual summary of our heuristic—or rules of thumb—for improving the integrating of SoP into ocean governance.

2. A Heuristic

2.1. Start From a Point of Collaboration

We see collaboration as the foundational principle as part of any work that seeks to incorporate SoP into ocean governance. From a research perspective, this begins with moving from siloed research towards multi-, inter-, and trans-disciplinary research (Kelly et al., 2019), approaches that seek to intentionally weave different knowledge systems together (Alexander et al., 2018). From a decision-maker perspective, this must start with removing the barriers that inhibit deep collaboration with research (Cvitanovic et al., 2015). Moving along the spectrum of engagement from consultation (stakeholders as inputs to research), to engagement (increasing involvement in research) and co-production (stakeholders as partners in research) can lead to increased knowledge sharing and knowledge uptake by end users (Cvitanovic et al., 2019). This is not to say that lower levels of engagement are destined to failure—they are often required when a research

direction has already been set (Reed et al., 2018), but certainly meaningful coproduction when time and resources allow can lead to useful and impactful research outputs (Duggan & Sokini, 2021).

One approach for achieving this is via deliberate efforts to co-produce knowledge through "iterative and collaborative processes involving diverse types of expertise, knowledge and actors to produce context-specific knowledge and pathways towards a sustainable future" (Norström et al., 2020, p. 183). It is critical, however, that the notion of co-production is far more than just a "tick box." Rather, it must involve deep, deliberate, and agile collaboration with all non-academic partners (Chambers et al., 2022; Muhl et al., 2023), which must include Indigenous and local knowledge systems (Gavin et al., 2015; Sterling et al., 2017). To this end, the notion of "two-eyed seeing" also provides a useful conceptual framework for equitably embracing multiple perspectives, knowledge systems, and values in coastal communities (Reid et al., 2021). Defined by Mi'kmaw Elder Albert Marshall as:

> Learning to see from one eye with the strengths of indigenous knowledges and ways of knowing, and from the other eye with the strengths of mainstream knowledges and ways of knowing, and to use both eyes together, for the benefit of all. (Bartlett et al., 2012, p. 355)

Two-eyed seeing is a framework that centres on a process rather than an outcome, valuing collective action built upon the shared understandings, insights, knowledges, and skills of different people and communities.

If resources and time allow, collaboration can be more targeted and efficient if underpinned by a formal stakeholder mapping process (Cvitanovic et al., 2016). This would include a focus on understanding the diverse values and goals of diverse actors at the onset to ensure initial engagement is informed by a mutual understanding/interest in the topic. This process may also minimise the risk of "too many cooks" that can occur when seeking more voices in such collaborations (Clement, 2022). Regardless of the approach used, starting from a point of collaboration creates time and space for the subsequent elements of this heuristic to occur.

2.2. Understand Your Positionality

Broadly speaking, one's positionality is made up of their ontology (how they view the world) and epistemology (how they generate knowledge; Moon et al., 2019a). An awareness of one's positionality, or how they fit in and interact with the world, provides crucial context around how one forms research questions, conducts research, interprets results, engages with stakeholders, and conducts and interprets every other step from knowledge production to implementation (Darwin Holmes, 2020; Moon et al., 2019b; Moon & Blackman, 2014). For example, an awareness of positionality may support stakeholders to understand whether they identify or are seen by others, as an insider or outsider to the area of study (Berger, 2015). An important consideration, particularly when seeking to incorporate SoP into ocean governance, given that an insider/outsider status could impact whether or not researchers or decision-makers have access to locations, the sort of data they are able to collect, and how it may be interpreted (Lusambili et al., 2020).

There are myriad ways for researchers and decision-makers to identify their positionality, from diaries and logs to peer consultation (Berger, 2015; Moon et al., 2016). It must be noted that simply identifying one's positionality is not a panacea. It does not change systemic barriers that reinforce biases (Nagar & Ali, 2003),

and there is a risk that some stakeholders will stop attempting to control their biases following the penning of a single positionality statement (Savolainen et al., 2023). Identifying positionality should not be a single act but instead a constant iterative process of reflexivity (Nicholls, 2009).

2.3. Understand and Define the Phenomenon

Developing a shared understanding and definition of SoP can support the flow of knowledge from research to decision-making (Tuohy et al., 2023), and in our experience, stands to provide avenues for meaningful input into ocean governance from a diverse range of stakeholders. SoP is a broad but contested phenomenon in the literature, that can at one time be described as something clear and tangible, and at other times complex and intangible (Duggan et al., 2023a, 2024a, 2024b). The debate (Stedman & Beckley, 2007; Williams & Patterson, 2007), conceptualisation (Tuan, 1974), and reconceptualisation (Raymond, et al., 2021) of the phenomenon is a good thing, it drives exploration and adds complexity to the conversation, but it also presents a challenge when seeking to incorporate the phenomenon into ocean governance (Duggan et al., 2024a). Ultimately, the final definition (or potentially multiple definitions) of SoP agreed upon by stakeholders is not the most crucial thing. Instead, the process of generating a shared understanding—what SoP is and what it isn't—is a key process that can serve to strengthen collaboration and increase the inclusion of diverse perspectives.

It is important to note that this shared definition is not about stamping out epistemic pluralism, but rather engaging with this diversity (Miller et al., 2008). The common definition should be about identifying points of overlap in different meanings of SoP. Stakeholders and non-academic actors can still hold true their individual definitions and associations of SoP (Raymond et al., 2021). There are several approaches that can lead to effectively developing shared understandings. Bracken and Oughton (2006) advocate for a common understanding between the natural and social sciences, driven by active listening and careful consideration of language. Lang et al. (2012) propose a comprehensive series of design principles that includes multiple steps designed to facilitate a shared understanding of terms. Polk (2015) begins to explore a tailored transdisciplinary co-production framework that includes stages for integrating knowledge from different groups. We would advise against overcomplicating this process, instead tailor the method to suit the stakeholders involved. Co-production approaches are one proven approach to drawing out common understandings (Nyboer et al., 2023; Polk, 2015; Schwilch et al., 2012). This shared understanding is the first step in identifying shared measures of success and shared goals, which further increases the likelihood of successful transdisciplinary research (Cvitanovic & Hobday, 2018; Norström et al., 2020).

2.4. Consider the End Point of the Data

A key challenge in integrating SoP into ocean governance is ensuring that the scientific information generated is salient for decision-makers (Duggan et al., 2024a, 2024b). This is a challenge faced in environmental and societal research more broadly (Kueffer et al., 2012). Certainly, increased meaningful collaboration, including co-productive research approaches (as outlined in Section 2.1), would aid this by driving improved decision-maker understanding of the constraints faced by researchers and, vice versa, an improved understanding for researchers of the process of policymaking as well as the logic behind appropriateness and meaningfulness of information (Cairney & Kwiatkowski, 2017; Dewulf et al., 2020).

Achieving this improved understanding is not necessarily a straightforward solution and, unsurprisingly, much of the literature focuses on what researchers can do to engage decision-makers. Evans and Cvitanovic (2018) outline a series of practical steps that researchers (and particularly early career researchers) can take to increase the likelihood of their work having a policy impact, from identifying who is involved in the policy process, building a public profile, building relationships, and contributing to policy discussions. Rose et al. (2020) advocate for increased awareness and the ability to capitalise on policy windows—those discrete periods of time where the chance of policy impact is increased. Marshall et al. (2017) specifically outline 10 things for social scientists to consider to improve the extent to which their research is salient to decision-makers, while Cvitanovic et al. (2021, 2024) provide empirically grounded guidance for building trust among academic and non-academic actors to increase the salience and use of data in decision-making.

On the other hand, there is some work dedicated to understanding how decision-makers can be actively involved in the research process. Kueffer et al. (2012) recommend ensuring there is time and space for a dedicated problem-framing phase in research design so that targeted research questions can be devised and outputs planned that address policy requirements. Gluckman et al. (2021) advocate strongly for dedicated knowledge brokers to aid in information transfer (Cvitanovic et al., 2025). Another consideration to increase the uptake of information into decision-making lies in framing. Cairney and Kwiatkowski (2017) highlight the importance of framing evidence in a way that is tailored to what decision-makers demand and understand. This tailoring should begin by clearly defining what we mean by the "place" in SoP.

2.5. Define the Place(s)

A shared understanding between stakeholders on where the study will focus and how SoP will be measured is crucial (Balvanera et al., 2017). As with a shared definition, the exact location is not the most important decision. Largely this can be driven by research and policy priorities. The key requirement is shared agreement and understanding of the drivers behind choosing that location.

Related to the question of where to measure SoP, is the issue of scale. As Lewicka (2011, p. 211) states: "The favourite target of place attachment research is neighborhood, followed by home, city and, much less often, national regions and continents." The issue here, though, is that these definitions of scale aren't necessarily standardised or used consistently between disciplines. Recent research has measured SoP at many scales, from the watershed (Almeida-García et al., 2020) to intra- and inter-town (Artmann et al., 2020; Lai et al., 2017), regional (Kirkpatrick et al., 2018), and the country level (Sijtsma et al., 2019). The articulation of these spatial scales is often inconsistent. For example, a city or town can range in spatial size and population. In addition, places are spatially layered phenomena, whereby one place can sit inside another (e.g., a suburb within a city, within a country; Relph, 1976; Tuan, 1974). All this is to say that identifying and articulating the scale you are investigating is important, particularly if you seek to make comparisons between places (Lewicka, 2011). When seeking to incorporate SoP into ocean governance, the most logical approach would be to set boundaries that effectively reflect how people interact with nature (Atwell et al., 2009). Some methodologies, such as auto-photography, can actually let that scale emerge and be refined throughout the data collection process (Devine-Wright & Wiersma, 2021).

2.6. Define the How

A shared understanding of how SoP will be measured (as a precursor for inclusion in policy) allows for appropriate research program design to support policy formulation. The process builds on the principles of co-design and co-production discussed earlier, and can enable trust between stakeholders and more resilient governance (Chambers et al., 2021; Coleman & Stern, 2018; Johnson et al., 2019; Lacey et al., 2018; Lockwood et al., 2010). It is important to note that when we say "measure" we are not referring to purely quantitative approaches, but are referencing all the ways SoP could be described, understood, and articulated.

Lewicka (2011) provides a sound overview of approaches for capturing a component of SoP (place attachment) and supporting the process of defining the how. Novel approaches can also help in this regard, such as Public Participation Geographic Information Systems, which have received increased attention in recent times (Brown & Reed, 2012; Brown et al., 2017), as has auto-photography (Devine-Wright & Wiersma, 2021). We would advocate for tried-and-true approaches when the end goal is policy impact. However, if resources are such that novel approaches can be explored, there are a range of emerging and promising techniques for capturing SoP, particularly in the area of soundscapes, or how people perceive and experience sound in a given context (Bai et al., 2024; Korpilo et al., 2023).

It would be remiss at this point to not acknowledge the systemic and resource constraints that limit research and policymakers alike when deciding methodologies for research programs. The methodology for measuring SoP will inevitably be driven by expertise, time, and cost constraints (Duggan et al., 2023a, 2024b), but where possible we advocate for mixed methodologies, offering both a depth and breadth of understanding (Bryman, 2006, 2016). When considering the exact approach, there are myriad effective examples outlined.

2.7. Focus on the Bright Spots

There is a dominant focus on understanding and overcoming "gaps" when it comes to the science-policy interface (Van Kerkhoff, 2014). We would posit that while learning from failure is a valid and important process, the repeated focus on negatives limits progress in research, and it is likely that the same is true in the policy sphere. Emerging research practices that focus on bright spots or "instances where science has successfully influenced policy and practice—and the sense of optimism that this can inspire" (Cvitanovic & Hobday, 2018, p. 1) are demonstrating a way forward to ensure that SoP can cross the science-policy interface (E. M. Bennett et al., 2016; Karcher et al., 2022, 2024).

In the realm of research, the existing examples of SoP specifically being incorporated into policy are limited but growing (Karcher et al., 2021). We can point this to the identification of policies that protect SoP (Pourbahador & Brinkhuijsen, 2023) and research that is purposefully designed for uptake by decision-makers (Brown & Raymond, 2007; Jayakody et al., 2024; Raymond et al., 2009). More broadly, there are frameworks for the incorporation of social values into conservation policy (Manfredo et al., 2021; Whitehead et al., 2014). As the literature in this space grows, it will be important to acknowledge and leverage examples of success. As with all the rules to date, this is not the role of researchers alone, and for all the relevant bright spots to emerge, and be championed, decision-makers will need to share their lessons. The most effective approach to promoting bright spots will depend on context but, as a starting point, the creation of a community of practice across the science-policy divide shows promise (Duggan et al., 2023a).

3. Conclusion

These seven rules of thumb are intended to enable researchers and decision-makers to more effectively support the incorporation of SoP into ocean governance. We acknowledge that broader-scale systemic issues and barriers must be addressed as a matter of priority to ensure appropriate knowledge integration, but believe that SoP can be a key tool in achieving this. Despite its amorphous and complex nature, SoP can still be innately relatable if collaboration and co-development of understanding are central concepts. Even if SoP changes between individuals, groups, places, and scales—it still exists. And recognising and identifying one's SoP and acknowledging the existence of SoP in others can be a great unifier. Research shows us that using SoP as a tool for relationship-building and sense-making between people is possibly the phenomenon's biggest strength (Duggan et al., 2024a, 2024b). Simply by acknowledging its existence, researchers and decision-makers stand to be able to familiarise themselves and others with the phenomenon. This can be a powerful first step in driving systemic change around the acceptance of SoP and recognition of its value as a key tool in ocean governance.

Conflict of Interests

The authors declare no conflicts of interests.

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ARTICLE

The Shortest Nuclear Route to Climate Change to Great Power Competition: Tracing Arctic Security

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Abstract

Arctic security has been growing in popularity across academia, policymaking, and news media. However, this popularity has come with a notable question: What does Arctic security mean, and how/what knowledges underpin it? This study traces the discourse on Arctic security from the Cold War to the present examining the emergence of different types of security which range from more traditional variants to wider and deeper readings such as environmental and comprehensive security. I identify key strands of Arctic security discourse, trace their interaction over time, and periodize the region. While the Cold War era was dominated by nuclear and traditional security logic, there have been three main shifts since then including (a) the 1990s–2007, (b) 2007–2019, and (c) 2019–present. This research finds that Arctic security knowledge follows global security trends. Thus, as security has widened and deepened globally, so too have the potential meanings of Arctic security expanded. However, there is a clear hierarchy in today's general discourse with what issues take center stage for the Arctic such as great power competition and climate change. This is in contrast to the Arctic Council, which takes into account all but military security definitions for Arctic security and integrates them in a relatively balanced way. This has implications for ocean governance institutions and the degree to which traditional military security concerns should be left out of broader ocean governance.

Keywords

Arctic; Arctic Council; governance; knowledge production; security

1. Introduction

From the *New York Times* headlines portending a new Cold War in the Arctic to the vast expansion of online panels and conferences where experts debate what should be done about Russia, China, and climate change,

Arctic security has gained significant traction in recent years (Kuus, 2023; Steinveg, 2021). However, this popularity has come with a notable caveat, the question of what knowledges underpin the concept of Arctic security and how that process of knowledge production conditions how we think about Arctic security today. In this article, I trace the production of different types of Arctic security knowledge—with many diverging meanings that mean anything from food security, increasing great power competition on the world stage, a warning sign for climate security, and many other definitions. By showing how knowledge has been produced around Arctic security, we can better see what, if any, hierarchies exist within these different sub-types of security and how their integration into ocean governance structures such as the Arctic Council can provide lessons for ocean governance writ large. Ocean governance here is defined as the social processes, rules, laws, norms, institutions, and discourses that shake our behavior, decisions, and actions surrounding the ocean (Partelow et al., 2023). By its very definition, this includes land-based society, how this society uses the ocean, and the physical characteristics of the sea itself. Ocean governance is a broad term and encompasses many different topical areas including fisheries, marine spatial planning, seabed mineral resources and mining, shipping, the costs of pollution, and scientific research amongst many others. The diversity of topics is only exceeded by the number of actors and systems that are also involved including individuals, companies, states, international organizations, and systems that take part. Tracing Arctic security discourse has important takeaways for the broader study of ocean governance as it is through the understanding of discursive trends and shifts that the dynamics of power that underly all governance structures can be made visible, both exposing their biases and also the conditions under which they operate.

For this article, I periodize Arctic security dynamics into four times: the Cold War, the 1990s–2007, 2007–2019, and 2019–present. Such periodizations reflect not only the work of other Arctic security scholars but also reflect key moments in the Arctic, such as the creation of the Arctic Council, the planting of a flag at the North Pole on the sea floor (2007), and the Pompeo's 2019 speech at the Arctic Council calling the region a zone of competition (Huebert, 2019). Importantly, such periodizations often co-exist and are dialectical in nature.

Unsurprisingly, I find that Arctic knowledge has been produced in many different ways—changing over time and place. Since the Cold War, there has been a steady trend towards increasing types of Arctic security knowledges produced, beginning with simply traditional hard security concerns and moving to including environmental security, human security, comprehensive security, and even food security. The production of these different types of knowledge is conditioned by geopolitical circumstances (Andreeva & Hønneland, 2023). While the Cold War limited the production of Arctic security knowledge to matters of nuclear weapons, the end of the Cold War opened the door for different types of knowledge production. The institutions that formed in the wake of the Cold War, specifically the Arctic Council, have expansively integrated these knowledges into their governance structures. Environmental dimensions of Arctic security—particularly that of climate change—are a central part of the Arctic Council's work. Similarly, human and comprehensive security have entered the repertoire of the Arctic Council and are key parts of the reports that the Council produces. That being said, the production of Arctic security knowledge began to center around great power competition and climate change from 2007 onwards and has revolved primarily around these two types, leaving others on the periphery when it comes to scholarly discussions and national Arctic policies. The link from knowledge production to governance integration is certainly an important liminal space to investigate. However, given the limitations of this article, I have left such research to future scholars of Arctic expertise and ocean governance.

Understanding and tracing the production of Arctic knowledge and its integration into the Arctic Council has particular resonance today when the structural conditions of great power competition seem to have dominated the usage of the term security even outside of the Arctic region. Acknowledging other types of security is more important in this environment filled with geopolitical tension, particularly illustrating the potential benefits of keeping hard security matters out of ocean governance structures. Moreover, the exercise of tracing the concept of Arctic security provides historical context and grounding for today's regional security debates, giving more agency and voice to other types of Arctic security that otherwise have become sidelined in the academic literature on the topic.

In Section 2, I begin with a brief overview of my methods as well as an explanation of different types of security logic that I used to shape my results. Then, I turn to my different periodizations: the Cold War, the 1990s–2007, 2007–2019, and 2019–present. I finish with a discussion describing how there are serious implications for the hierarchical centering of great power competition and climate change as how we understand Arctic security in general discourse today, but that the Arctic Council's lack of military security in their mandate may provide lessons for how to avoid hierarchical integration in ocean governance structures.

2. Knowledge in Politics

Scholars have observed the increasing importance of knowledge in politics as modern society has grown more technological and complex (Christensen & Holst, 2017; Douglas, 2009; Fourcade, 2006; Kitcher, 2011; Markoff & Montecinos, 1993; Turner, 2003). Knowledge has always been important to decision-makers in security politics, whether one considers how states decide to invade which territory, which regions to colonize, or what weapons to build. There are serious questions that are raised when one is asked how knowledge is produced when it comes to matters of security and whether and how they become integrated. Knowledge in ocean and polar governance is even more complex, with a variety of different issue areas overlapping such as economic issues, security disputes, geopolitical conflicts, and environmental crises—all of which compete for attention in these increasingly important regions of the world (Otto & Menzel, 2024; Wehrmann & Zimmermann, 2022). While the integration of knowledge would have overall positive benefits for ocean governance in general, understanding how such knowledge is produced and then integrated is still under study (Paola et al., 2021).

To better understand how knowledge is produced and integrated surrounding the concept of Arctic security, I turn to concept tracing. Tracing the history of a concept is a time-tested method in international relations, specifically through exploring the role of discourse. Rather than taking a sociolinguistics approach or a poststructuralist approach, this research follows in the steps of Hansen (2006)—specifically her work understanding how NATO member states began to understand the Balkan war and interpreted the Balkan as violent. There are certainly alternative approaches to the analysis of discourse such as that of sociolinguistics which privileges the structure of language and the social, cultural, and political aspects of language and that understands language as having meaning only in and through social practices (Gee, 2005, 2011). Others may take a critical discourse analysis approach that emphasizes the dialectical relationship between discourse and society, understanding discourse as "devices that can foster common perceptions and understandings for specific purposes" (Howarth & Stavrakakis, 2000, p. 3). In short, for these scholars, discourse can have a causal effect. Poststructuralist approaches to discourse analysis suggest that there is no distinction between discursive and non-discursive realms (Laclau & Mouffe, 2001). However, Hansen's (2006) work—which

builds on a poststructuralist approach—is particularly useful for the research on concept tracing as it attempts to uncover how meaning behind discursive representation is produced and what meaning underlies them. Thus, tracing a concept such as "Arctic security" and attempting to understand how its meaning has shifted over time falls in this theoretical tradition. I define discourse here as "a system producing a set of statements and practices…construct the reality of its carriers and maintain a certain degree of regularity in a set of social relations" (Dunn & Neumann, 2016, p. 125). As I was interested in understanding the production and integration of Arctic security knowledges, I incorporated both academic discourses from the scholarly community as well as relevant state behavior documented in key texts, and critical governmental documents.

For this review, I used a variety of different databases searching for the term "Arctic security" including Web of Science, ProQuest, and Google Scholar, as well as searched through presidential libraries (where available online), openly available information on the CIA's reading room, and specifically explored the libraries of key Arctic think tanks such as The North American and Arctic Defence and Security Network (NAADSN) and the Arctic Institute. By using broad databases such as Web of Science, ProQuest, and Google Scholar and an approach that only privileged the term "Arctic security," I aimed to cover as many documents as possible. I was particularly interested in the academic discourse in question and thus I aimed to look primarily at academic sources to emphasize how the discourse on Arctic security in the scholarly community has developed. Other discourse on Arctic security in newspapers and more public discourse settings has tended to be more reactive in the past and does not fully encompass the nuance of the academic discourse on the topic. Moreover, when presidential libraries had online resources, I searched using "Arctic security" again as a concept to see how meaning was produced. To specifically find discourse that might not be present in academic sources, I also gathered documents from two key Arctic think tanks including NAADSN and the Arctic Institute. In total, I assessed 265 articles, of which 12 fell into the Cold War period, 36 fell into the 1990s–2007 time period, 89 fell within the 2007–2019 time period, and 128 fell into the 2019–present period. Importantly, the collection of these articles was stopped in mid-2023 as the article was being drafted and thus many more articles have likely been published since then. Selected key documents are cited below.

Once I collected the documents, I read through each and categorized each through an inductive manner for specific themes that emerged such as maritime issues and the centrality of nuclear weapons as well as the meaning of security that underlined "Arctic security," for example whether the security encompassed questions of environmental, comprehensive, military, human, and food objects. Each document could have more than one code. Once I coded each document, I classified them based on the time period in question and analyzed the extent to which some meanings of security competed with or self-reinforced the overall production of the concept of "Arctic security." To explore how these discourses integrated into Arctic governance, I analyzed the publications from the Arctic Council to see to what extent the produced meaning of security was found in public-facing publications and the general zeitgeist of the era in question.

3. Cold War

3.1. Production

During the Cold War, traditional security knowledge shaped how the Arctic was understood as a military front (Østreng, 1989). Arctic security thus was about the place (Nieminen, 1991) it played in the rivalry between the US and the Soviet Union whether through aerial bomber routes, submarine capabilities, the development

of radar systems across the North, and alliances like the North American Aerospace Defense Command. Thus, the primary type of knowledge produced around Arctic security was dominated by concerns about how to produce knowledge about nuclear weapons in the Arctic and defending from nuclear weapons primarily due to the hegemonic nature of the Cold War.

Characterized by being the only region that lay directly between the Soviet Union and the US, Arctic security was ruled by certain types of traditional security knowledge (primarily nuclear security) during the Cold War. Scholars and practitioners alike understood the region as a theatre of competition between the US and the Soviet Union—one where strategic bombers and nuclear-armed submarines could deliver nuclear weapons to their opponents (Jalonen, 1988; Østreng, 1991). As the technological development of nuclear submarines accelerated, the region transformed from one characterized by aerial defense and offense to that of submarine warfare. This was particularly important for the Soviet Union, as such changes in technology meant that they too had to modernize their submarine strategic nuclear weapons that were hosted with the Northern Fleet (Critchley, 1984; Østreng, 1991). Knowledge production around Arctic security was limited to topics including the importance of power projection, deterrence, and naval interaction among the great powers (Miller, 1992; Osherenko & Young, 1989). In tandem with the development of these weapons, so too came the rise of radars and alliances such as the North American Aerospace Defense Command to detect them, which began to litter the North (Charron & Fergusson, 2020; Sokolsky, 1986).

Some have suggested the region was narrated through particular concepts: (a) the Arctic as an aerial attack corridor, (b) the Arctic as home to a second-strike nuclear-powered submarine force, and (c) the Arctic as home to a series of radar systems (Frederick, 1987). In other words, "security considerations were cast only in military terms" (Huebert, 2000, p. 101). Further, the "gradual inclusion of the North into Cold War strategic planning made most governments conceive of Arctic security solely in military terms" (Østreng, 1999, p. 22). When discussing Arctic security in their seminal 1989 book *Age of the Arctic*, Osherenko and Young primarily focus on questions of nuclear weapons, emphasizing the narrative of the Arctic being the shortest air route between the US and the Soviet Union in the early days of the Cold War, the maritime areas of the Arctic as key strategic areas for ballistic missile nuclear submarines and high endurance manned bombers equipped with air-launched cruise missiles (Osherenko & Young, 1989). Griffiths' 1992 *Arctic Alternatives*, a second key book that outlines the Cold War era thinking of the Arctic understood security and Arctic militarization as being driven by extra-regional security requirements of the US and the Soviet Union. In other words, even though the Arctic wasn't the source of military security issues, it was militarized by the East–West conflict, the development of military technology (Griffiths, 1992), and the geostrategic conditions of the Arctic—visible in the shift in aerial to submarine technology.

3.2. Integration

During the Cold War, there was no region-wide Arctic governance implementation. Nonetheless, there is evidence that the production of this knowledge that surrounded traditional security made its way into states. When looking through the Eisenhower, JFK, and Truman presidential libraries, the only time the Arctic came up was in reference to nuclear weapons—whether in reference to concern about Soviet nuclear long-range bomber flights in 1958 or to Soviet nuclear-powered submarines in 1963 (Central Intelligence Agency, 1958). Similarly, Danish and Greenlandic understandings of the Arctic were primarily shaped around Greenland's strategic location as it had to do with global nuclear defense (N. Petersen, 1988). The *Canadian*

White Paper on Defence (Government of Canada, 1987) characterizes the Arctic Ocean as a region of strategic importance, specifically as it relates to the Soviet nuclear capabilities. Not only does the document call the Arctic an "operating area for submarines" but it also calls it a "battleground" linked in tandem with the development of nuclear power (Government of Canada, 1987, p. 50). Only concerns about nuclear weapons—both in the air and under the sea—and some rhetoric around radar systems are integrated into the limited documents available on Cold War Arctic thinking, suggesting that the geopolitical constraints from the US–Soviet Union ideological conflict made only certain types of knowledge palatable for states.

4. The Immediate End of the Cold War: 1990s–2007

4.1. Production

With the end of the Cold War, so too came the emergence of many different types of Arctic security knowledges. Some suggest that this shift in this thinking came from Gorbachev's seminal Murmansk 1987 speech, the international shift towards a comprehensive view of security, and the shift from an East–West dichotomy in the Arctic to a regional understanding of security (Østreng, 1999).

Perhaps the most distinct change was the sharp increase in concerns about environmental security and calls for increasing knowledge on the issue. Arctic security knowledge was produced more surrounding issues of environmental degradation and pollution, pointing to concern regarding the melting of permafrost, sewage, Arctic haze, and pollutants (Eriksson, 1995; Lamb, 1994; Østreng, 1991). It wasn't until the 2000s that environmental security began to include specific articulations of threats to the climate and the health of Arctic residents (Huebert, 2000). Some language also began to emerge around climate change as a threat multiplier to the Arctic, alongside specific issues that were again tied to access such as the opening of the Northwest Passage, the Northern Sea Route, and the access to natural resources (Goodman, 2017).

Other subtypes such as comprehensive and human security knowledges, while not popular, began to emerge during this era as well. Comprehensive security was originally formulated in the Brundtland Commission in the late 1980s while human security was written about first in the United Nations Development Programme 1994 report. Academic literature on human security and comprehensive security, however, is difficult to find in this early era. Instead, it appears that while different types of concerns— environmental, health, energy, and economic—were recognized as problems in the Arctic, they were not understood as distinct forms of knowledge.

This increase in concerns about the Arctic environment was also blended in some cases with traditional security logics—suggesting that measures should be taken to form institutions to protect both. This is not to say that traditional security knowledge that was produced on Russian military actions in the Arctic went away (Huebert, 2000; Lamb, 1994), but rather that their emphasis on deterrence and military build-up transformed into knowledge that instead emphasized the building of regional security alliances and institutions to create security (Young & Cherkasov, 1992). In tandem with this turn to knowledge integrated into regionalization, there was also a shift towards the production of knowledge that brought together concerns about environmental and traditional security concerns. Huebert wrote in 1999 that while questions of environmental security were becoming central for the Arctic such as the protection of the environment, traditional security concerns didn't go away in its wake. Rather these issues transformed into

questions of arms control, nuclear waste, and military technology development (Huebert, 1999). One specific case of how traditional security logics shifted into a more environmentally minded type of concern is that of nuclear waste. Some were explicit that the largest threat to security in the Arctic was the storage, handling, and disposal of nuclear waste in the Russian Arctic (Abelsen, 1999). They suggested that nuclear waste on the Kola Peninsula was not stored properly, that liquid and solid waste were dumped into the Barents Sea and if unmonitored could lead to catastrophic environmental results.

4.2. Integration

The end of the Cold War saw the explosion of regional initiatives in the Arctic, many of which integrated certain types of knowledge that were being produced around Arctic security. The end of the structural constraints of the Cold War as well as the vast expansion of different types of Arctic security knowledge made the further integration of many of these knowledges possible. Much of this integration came from the formation of the 1991 Arctic Environmental Protection Strategy—later the Arctic Council—which by its very nature leaves out discussions on military security. By contrast, cooperative security knowledge was used in promoting the Arctic Council as "exceptional" and the region as "exceptional" in tandem with the rise of liberalism (Koivurova & VanderZwaag, 2007; Stokke & Hønneland, 2007; Young, 2005). Similarly, specific knowledge on Arctic environmental security threats was produced and integrated into key reports on nuclear-ecological problems in the Arctic including an influential International Institute for Applied Systems Analysis 1996 report (Andresen, 1996), and an Arctic Council Arctic Monitoring and Assessment Programme report from 1997 and 2002 (AMAP, 1997, 2002). A 2004 report from the Arctic Council even mentions that there are serious concerns about nuclear-ecological problems in the Murmansk and Arkhangelsk regions including nuclear submarines, nuclear weapons testing on Novaya Zemlya, nuclear power plants on the Kola Peninsula, and waste in the Barents and Kara Seas (Arctic Council, 2004). Human security, while absent in this particular wording, is also present in the Arctic Council's *Arctic Human Development Report*—written and researched from 2002–2004. Some even conceptualized the Barents initiative as a type of comprehensive security that included "military, environmental, economic, cultural, political, and other issues" (Eriksson, 1995, p. 262). In short, the very creation of the Arctic Council as one that left out military security discourse allowed for the vast expansion of security discourse, ultimately permitting the institution to cover the vast number of issues included in discussions of ocean governance without forcing them to compete with one another for dominance.

The end of the Cold War heralded a new type of Arctic security knowledge, one that emphasized the importance of environmental concerns—particularly those of climate change. However, rather than fading away entirely, the discourse of Arctic security that focused on traditional threats and logics shifted to blend towards an environment-traditional discourse that opted for different types of responses to regional threats. Institutions instead of nuclear submarines. Security alliances rather than militarization. That traditional threats and logics did not disappear entirely is particularly notable as it illustrates that the region was not obliquely ignoring the very real issues at play but rather this era offered an opportunity for the inclusion of new securities in tandem with old concerns. The rise of comprehensive and human security in the Arctic, while early, also pointed towards the expansion of knowledges at play, some of which were integrated into Arctic governance arrangements.

5. The Beginning of an Arctic Boom 2.0: 2007–2019

5.1. Production

While it appeared that traditional security knowledge had faded into the background for the Arctic in the wake of the Cold War, it came roaring back with a vengeance (Kraska, 2011). Much of this can be attributed to how states behaved in the Arctic. Russia restarted their long-range bombers patrols which triggered states like Norway to reevaluate their Arctic policy with a new High North Initiative. However, it was Russia's flag planting on the "North Pole" in 2007 as a claim to part of the continental shelf that kickstarted much discussion of territorial ambitions and resource claims. These expanding types of security knowledges were mirrored in discourse which was dominated by the reemergence of great power competition and scramble narratives as well as the looming threat of climate change. However, this era also saw an increase in the discourse of Arctic human security. Expanding types of Arctic security knowledge can be directly connected to changing global security realities—not the least of which was the 2014 Crimean Annexation and increasing tensions between China, Russia, and the US.

The two most prominent scholars that exemplify this expanding interest in Arctic security are the knowledge debates between Canadians Rob Huebert and Whitney Lackenbauer, who stood on different sides of the Arctic security debate. Huebert and those who used the language of traditional Arctic security emphasized the importance of hard security challenges and climate change, exploring how warming temperatures and accessibility could be drivers of military competition (Gorenburg, 2012; Huebert, 2010, 2011, 2018; Huebert et al., 2012). These scholars also emphasized the role of China as a potential threat and Russia as a continuing threat (Flake, 2017; Konyshev et al., 2017; Lasserre et al., 2017; Lundestad & Tunsjø, 2015; Sergunin & Konyshev, 2014). By contrast, Lackenbauer suggested that Arctic scramble rhetoric used scare tactics to justify investments in national defense, serving short-term military interests rather than the longer-scale threats of climate change and human security, arguing that there was no Arctic race and true boundary disputes (Lackenbauer, 2010, 2014). This debate around the nature of Arctic security knowledge met what Griffiths (1992, p. 26) called "purveyors of polar peril"—those who linked the melting of sea ice, the new availability of natural resources in the region, and rising great power competition as part of a "scramble for the Arctic" (Borgerson, 2008; Murray, 2012; Sharp, 2011).

Climate change also continued to become more central to how most understood Arctic security—as both a homeland and national security issue as well as a bellwether for how climate change would shape global geopolitics (Avango et al., 2013; Gerhardt et al., 2010; Keagle & Mann, 2012; Lanteigne, 2016). For most, this meant prioritizing climate change as the main threat to the Arctic but tying it closely with geopolitical issues (Nicol, 2020). More accessibility due to melting sea ice would mean more oil and gas, shipping, and fishing—all with security consequences, both hard and human security in nature (Goodman, 2017; Lackenbauer, 2011).

Human security knowledge related to the Arctic also saw an enormous increase during this time (Nicol & Heininen, 2014). From 2007–2009, a project at Tromsø University specifically focused on human security in the Arctic led by Hoogensen Gjørv (Hoogensen Gjørv et al., 2009). She and others developed a multidimensional picture of Arctic security, drawing together strands of threats to the Arctic environment identity, food supply, community health, economic opportunity, and political stability (Hoogensen Gjørv et al., 2013). By 2019, human security had become a key part of the discourse surrounding Arctic security as

was particularly clear in the Arctic Yearbook's 2019 issue where an entire section touched on human security approaches (Goes, 2019; Middleton, 2019; Vuillerme, 2019; Zojer, 2019). The language that alluded to comprehensive security continued to be used across most of the other schools of Arctic security thinking although it was found far and in-between such as one article on why a comprehensive security approach was best suited for Arctic analysis (Hoogensen Gjørv & Hodgson, 2019), a conceptualization of human security (Heininen, 2014), and a project on a comprehensive approach to Canadian Arctic security (Ackren & Jacobsen, 2014).

Other very specific types of security knowledge began to emerge including food security. However, interestingly, the literature is quite divorced from other Arctic security texts and makes up its own relatively small corpus. Food security scholars emphasized resource sharing in Nunavut (Harder & Wenzel, 2012), food insecurity in the North American Arctic (Cruickshank et al., 2019; Loring & Gerlach, 2015), and Inuit food security—tending to emphasize Indigenous perceptions of insecurity (Ford & Berrang-Ford, 2009; Ford et al., 2006). Importantly, this is not to imply that there wasn't insecurity for Indigenous People before this time, but rather the language of security was beginning to be used rather than that of environmental resilience, economic development, and cultural identity.

5.2. Integration

These expanding knowledges were taken up in many cases by the Arctic Council. Environmental knowledge has always been a part of the Arctic Council given its history as the Arctic Environmental Protection Strategy so it is no surprise that climate change, environmental degradation, permafrost measurement, and tools for adaptation come up often in the reports from the Council during this era (Arctic Council, 2016). The boom in human security knowledge was also mirrored in the Arctic Council, specifically in its 2010 *Arctic Human Development Report* as well as the 2015 AMAP *Assessment on Human Health* and the 2017 *One Health Report*. These reports all illustrate that human security needs were being incorporated into the Council's work. While comprehensive security as a term was not used in Arctic governance, the recognition that Arctic security must incorporate multiple types of security knowledge was clearly there and played a role in the Council's work. As expected, the Council does not include military security as part of its mandate so knowledge on great power competition and hard security are not visible. The vast number of reports—of which only a few notable ones are mentioned in this section—does much to illustrate the productivity of the Council, notably showing that the expansion and inclusion of additional securities did not hinder its capacity to create new knowledge. The lack of military security perhaps actually was permissive in allowing this enhanced emphasis on human security even while geopolitical tension occurred outside the Arctic.

Marked by many significant geopolitical events, this era showed definitively that Arctic security discourse was inherently linked to geopolitical conditions. Moreover, this expansion of different types of Arctic security knowledges was met by a division between two hegemonic sub-types of knowledge, those surrounding great power competition and climate change. By contrast, many other types of knowledge such as human, comprehensive, and others tended to be less integrated although environmental and human security knowledges were clearly part of Arctic governance.

6. Explosion: Arctic Security 2019–Present

6.1. Production

Since 2019, Arctic security knowledge has again shifted alongside global security trends with knowledge production on the rise (Aksnes et al., 2023). Concern around global great power competition inordinately conditions how Arctic security discourse handled threats in the region—with many focusing on Russia and China. Paired with this is climate change as an important type of threat to the Arctic environment. States have primarily turned to these two drivers of Arctic security as the primary concerns, which has in some cases left out other types of securities such as human security and Indigenous security from governance integration.

The most dominant Arctic security knowledge produced since 2019 draws upon great power competition and the role of global strategic rivalry (Dean & Lackenbauer, 2019; Huebert, 2019; Lanteigne, 2019; Østhagen, 2020; Wither, 2021). Interestingly, such threats are also expanding and now include literature on hybrid warfare and the information domain (Bouffard & Carlson, 2023; Kertysova & Gricius, 2023; Lackenbauer et al., 2022; Østhagen, 2023). One of the more influential pieces by Lackenbauer (2021) distinguishes between threats through the Arctic (i.e., great power competition and global security dynamics), and threats to and in the Arctic (i.e., climate change). China's expanding geostrategic interests that include the Arctic are also a central topic in debates on Arctic security arguing that global competition between China and the West could spill over into the Arctic (Brady, 2019; Lackenbauer et al., 2022; Lajeunesse & Choi, 2020). However, Russia is also a central concern—particularly its military modernization and expansion (Buchanan, 2023; Lagutina, 2021; Lanteigne, 2019; Moe, 2020; M. Petersen & Pincus, 2021).

However, those approaching Arctic security through a traditional security lens also acknowledge that the region is vulnerable (in a security light) to climate change (Bouffard et al., 2020; Nicol & Chater, 2021; Østhagen, 2021) which has downstream impacts on Arctic residents and maritime security including search and rescue, sea conduct, and fishing (Huebert, 2021; Lanteigne, 2019). In other words, traditional and environmental security are no longer different types of security, but rather two sides of the same coin (Nicol, 2020). That being said, language on climate change as a threat multiplier is also present in the majority of pieces that touch on Arctic security—both in a traditional and environmental sense. This threat multiplier can be linked to natural disasters, infrastructure, governance, resource scarcity, shipping, economic opportunities, and military operations. Climate change drives environmental changes and ecological changes that can be negative for the Arctic. However, there has also been a rapidly expanding body of work that brings specific attention to the human and environmental security nexus (Greaves, 2021; Lanteigne, 2019).

Many reports since 2019 have taken an obliquely comprehensive approach acknowledging the role of political, environmental, economic, energy, human, and technology-based security (Bouffard et al., 2020; NAADSN, 2020; Zandee et al., 2020). This is a relatively steady trend that can be found both rhetorically in most texts and directly in others. Since Russia's invasion of Ukraine in 2022, some are drawing connections between Russia's war in Ukraine and its ability to project power or reach its economic and energy goals in the Arctic or whether cooperation in the Arctic to solve broader security concerns can happen at all (Koivurova & Shibata, 2023; Sukhankin, 2022).

Human security perspectives have also continued to proliferate, taking an ever-wider picture of what security looks like in the Arctic including questions of resilience in the face of communities to disasters and cybersecurity (Gricius, 2021; Kikkert & Lackenbauer, 2021). Indigenous perspectives also take on an increasing role here that use direct security discourse, particularly in regard to climate change (Dorough et al., 2020), energy security (Kvern et al., 2022), and food security (Borish et al., 2022; Natcher & Ingram, 2021; Ross & Mason, 2020). Importantly, although these perspectives may seem "new," such issues have been central to Indigenous survival for decades including concerns about environmental protection, the preservation of Indigenous identity, and restoring Indigenous rights and self-determination (Kuokkanen & Sweet, 2020).

6.2. Integration

The steady increase of Arctic security knowledge has reached an all-time high since 2019. Much of this has been driven by an increasing turn to the Arctic by states themselves. For example, the US—which had last published an Arctic strategy in 2013 (although has since published a 2022 version)—released Arctic policies across each branch of the armed forces from 2019–2021, the first time such an event happened in its history. Similarly, Canada released the *Arctic and Northern Policy Framework* in 2019; Norway released a policy in 2021, and the US and Russia released their whole-of-government approach in 2022. However, what is a commonality of most Arctic security texts during this time is the emphasis on great power competition and climate change, although there is recognition that Arctic security is growing increasingly complex.

The Arctic Council is a particularly good example that illustrates how the different types of Arctic security knowledge are being integrated into governance arrangements. As in the above Sections 4 and 5, climate change and knowledge about environmental security issues have continually been a central part of the Arctic Council's work. During this era, many reports call upon the shockingly quick pace of warming in the region, and draw attention to persistent organic pollutants (AMAP, 2021a, 2021b), and concern about how the region will become more resilient (AMAP, 2019). Human security was also increasingly a topic in the Arctic Council, but many reports also integrated this type of knowledge with concerns about Indigenous security with reports covering a broad spectrum of topics such as engaging with Indigenous People, local communities, connectivity, gender equality, and food security. Other reports also explored youth engagement and a blue bio-economy in the Arctic. This was also the case with reports on food security, specifically the *2021 Indigenous Food Security in the Arctic* report and several others including the *2019 Arctic Food Innovation Cluster* that combined knowledge on food security, Indigenous security, and human security. Comprehensive security language again was not included per se but there were several reports that illustrated the comprehensive nature of security knowledge that the Council was taking into account such as the *2020 Arctic Resilience Forum* report which dealt with resilience for Indigenous youth, food security, renewable energy, human health, connectivity, gender equality, socio-ecological resilience, and infrastructure. In other words, the expansion of Arctic security discourse was met with the same type of expansion in governance. Similarly, military security knowledge was not included.

7. Discussion and Conclusion

The analysis of how Arctic security knowledge has been produced and integrated suggests two lessons: (a) general knowledge production on Arctic security has become hierarchical—centering those types of knowledge that address great power competition and security as geopolitical conditions have changed—;

while (b) the Arctic Council integrates human, comprehensive, and environmental security in a relatively balanced way and is resilient to shifts in global geopolitics. This has implications for how ocean governance institutions should prioritize different types of knowledge.

First, the general discourse on Arctic security is conditioned by geopolitical events, leading to a hierarchy of what types of Arctic security knowledge are centered. While in the Cold War, only traditional security knowledge was produced and counted as Arctic security knowledge, it faded into the background upon the end of the Cold War. As great power competition heated up globally, so too did traditional security re-enter the realm of Arctic security. This vulnerability to outside influence suggests that knowledge production on Arctic security is reactive to global happenings. This is not all bad. For example, the rise of climate change as a central concern in Arctic security has merits for how Arctic states and communities will address it as a key threat. That being said, this reactivity to global geopolitics also implies that some types of Arctic security have become more central and sedimented over time. Great power competition and climate change have become hegemonic ways of defining Arctic security since the mid-2000s. Although other types of Arctic security knowledge have been developed that take more of a human, comprehensive, or even food-based approach, they are not central in the main security debates over how knowledge is produced. This hierarchy and sensitivity of Arctic security discourse likely also has implications for who has the authority to produce such knowledge. For example, it may be that academic journals such as *Polar Journal* and *Polar Record* have been home to more traditional security debates during the Cold War rather than other security knowledges. Structural academic conditions surely also play a role such as the disciplinary nature of the political science field in particular that has conditioned what is security, as well as placing the Arctic as a case into broader questions of global environment and security—leading to this geopolitical sensitivity. There is also certainly a role for understanding the key institutions and universities that also play a role in this knowledge production such as research groups including the NAADSN and the Fridtjof Nansen Institute, universities such as the Royal Danish Defence College and the University of Lapland, and state-sponsored centers such as the Ted Stevens Center for Arctic Security Studies—such an analysis of this constellation deserves its article rather than a marginal analysis here.

Second, while the general discourse on Arctic security is reactive and hierarchical—the Arctic Council's integration of different types of Arctic security knowledge does not appear to be so. The Council has, since its onset, largely integrated human, comprehensive, and even food-based knowledges around the region in its many reports in a relatively balanced way. While the Council is limited in that it does not incorporate military security as part of its mandate, this may be a strength not only for diplomacy between Arctic states but for the very nature of Arctic security knowledge itself. When scholars and states describe and act on Arctic security, traditional military security tends to be predominant alongside climate change—a norm that is difficult to unseat. By contrast, the Council has the freedom to set aside military security and emphasize the interconnectedness of many other types of security knowledge, making it more resilient to the hierarchy of security knowledge otherwise present and the moods of structural geopolitics. This is certainly not to imply that other hierarchies do not exist within the Council. Many scholars have written about the hierarchies between the permanent participants and the Arctic Eight and the role of Indigenous people as actors in the Council via the lens of structural injustice (Wood-Donnelly, 2023). Future work might interrogate how a more expansive notion of Arctic security is not met with a similarly expansive and inclusive governance approach.

Together these findings have some implications for how ocean governance institutions should prioritize and integrate different types of knowledge. First, because general discourse on Arctic security is conditioned heavily by geopolitical events and leads in many cases to the sedimentation of a hierarchy of some types of security, it begs important questions of how different securities are put into a hierarchy in a maritime capacity. For example, in discussions on ocean governance, how do environmental security concerns such as those surrounding pollution or ocean acidification compete with military security questions such as those surrounding piracy or counterterrorism operations? The findings from the above analysis across the entire article suggest that such competition might be sedimented over time as well and that structural factors such as that of the Cold War and increasing geopolitical competition will also impact what topical issues ocean governance institutions can focus on. For example, the UNCLOS encompasses many different types of security discourse including the differing priorities of an environmental security perspective—understood through discourse on protecting the marine environment—and an economic security perspective—understood via access to marine resources and regulations on seabed mining, fishing, and oil extraction. UNCLOS also underlies the establishment of exclusive economic zones, which has military security implications. Likely these types of security compete with one another for dominance and geopolitical competition as a security discourse is extending to even UNCLOS. In 2024, Russia considered exiting UNCLOS and in 2023, the US announced an extensive continental shelf claim. Although the UNCLOS remains a central institution in ocean governance, the extent to which it can remain outside competitive discourse remains to be seen. Similarly, the International Maritime Organization (IMO) is faced with competing security discourses. While parts of the organization handle military security threats such as piracy, other parts handle environmental security issues including oil spills and emissions, and others still emphasize economic security regarding the IMO's mandate to ensure safe and maritime transport. However, here again, geopolitical competition as a structural variable may have serious consequences on how these securities compete, particularly given Russia's ousting from the IMO Council in 2022. In response, Russian ships, in some cases, are no longer complying with IMO requirements—making shipping more dangerous. Last, the shifting role of actors such as the EU and its increasing focus on ocean governance begs the important question of what security will the EU prioritize and to what extent will it be conditioned by structural factors and not allow for more nuance in its discussions of security in the world's oceans.

Second, the vast difference between how Arctic security is understood via general discourse versus the Arctic Council offers insights for governance institutions writ large. By their nature, ocean governance institutions are faced with a myriad of different knowledges and must make choices about which to prioritize. Should trade between countries and economic issues take center stage or military security threats or environmental concerns? When military security is a part of an ocean governance institution's mandate, it often ends up taking a central role. Thus, other issues are sidelined. As one example during the Cold War, there was little to no discussion on ocean governance regarding the many oceanic issues that plagued the Arctic Ocean including weapons dumping, overfishing, and other concerns. Due to the hegemony of traditional security discourse, other securities such as those of environmental issues were simply not part of the equation. A second example regards the pause of the Arctic Council in the wake of Russia's 2022 invasion of Ukraine. In the wake of the pause, all cooperation regarding climate and environmental security concerns was entirely paused. Suddenly, sharing data to deal with the threat of climate change was no longer an option for Western scientists, leading to a real failure of ocean governance to balance the different discourses of security, when the discourse of great power competition as a security discourse so clearly became dominant. Previously, the Arctic Council had been considered different in that military security was avoided at the onset of the institutions in the

mid-1990s. This ability to sidestep current geopolitical concerns and tensions between states has made it resilient to shifts such as the 2014 annexation of Crimea and even to some extent, the 2022 full invasion of Ukraine. While the Council did pause for a year, it has recently restarted the work of the working groups that draw upon human, comprehensive, and environmental knowledges. Even with this restart of relations, there is something dominant about military security discourse that enables it to overcome the importance of other securities. This has implications for ocean governance institutions in general and exploring to what extent military security is incorporated into other governance institutions such as the IMO and whether it has hindered the resilience of these institutions in the face of increasing geopolitical competition. While this is just one institution under analysis, future research could explore other ocean governance institutions to determine if indeed taking out military security as a type of knowledge has overall positive impacts for these institutions, leaving such discussions to military-based fora. Similarly, future research could also explore whether the vast number of ocean governance institutions tend towards specialization of certain types of securities or whether there are some similar to the Arctic Council and attempt to cover the vast breadth of issues inherent in an ocean context.

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Conflict of Interests

The author declares no conflict of interests.

Data Availability

The data that support the findings of this study are available from the corresponding author.

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ARTICLE

Stone Aggregations or Reefs? Knowledge Politics Around a Transboundary Seabed Complex

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Abstract

This study analyses marine governance and knowledge politics of sediments in the Borkum Reef Ground from a historical and German perspective, as well as in the context of litigation against marine gas production from transboundary Dutch and German fields. The authors analysed interview transcripts, project documents, environmental media campaigns, and notes originating from participant observation and stakeholder engagement. The study employs the science and technology and sociology of ignorance approaches. It asks which implications for biodiversity protection and ocean governance derive from administrative fragmentation and knowledge politics by a diverse set of actors. National divisions and prioritised knowledge production led to a shift in perception of the area from a transboundary seabed habitat to two distinct national marine areas and resulted in a fragmented *Schutzgebietskulisse* including marine protected areas, restoration zones, and unprotected zones. The study illustrates how the prioritisation of mapping marine protected areas may backfire on knowledge gain in potential industrial zones and overall marine protection.

Keywords

Germany; knowledge politics; marine gas; marine protection; North Sea; ocean governance; the Netherlands

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1. Introduction

This article originates from a naïve question: Where is the Borkum Reef Ground located? It was posed by the first author, a social anthropologist, when entering an interdisciplinary research project focusing on the German marine protected area (MPA) known as Borkum Riffgrund. Her task was to investigate the

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governance of user conflicts. By the end of the first project period, many project colleagues, including natural scientists equated the Borkum Reef Ground with the MPA, which was incorrect. Though they knew about marine connectivity and the meaninglessness of human-made borders to marine life and processes, they underestimated the political importance of scoping and mapping the habitat. Imaginations, however, influence ocean governance outcomes when communicating to policymakers or judges, because how can they understand the ecological implications of their decisions over marine industrial projects with only a vague idea of the spatial extent and nature of the affected habitat?

The major user conflict, a contested gas extraction project across the Dutch–German border, was easily identified through a systematic analysis of newspaper articles (Ittner, 2022). Since 2019, the Gateway to the Ems (GEMS) project has evolved into the most important user conflict in the German North Sea—involving two countries within a wider region (the Wadden Sea), crossing local to global levels, involving several court cases, and many protest activities. The stakes were high. The Dutch gas industry had invested more than €600 million in gas exploration and in the production of the platform. The German government faced the consequences of the Russian invasion of Ukraine on national gas security, and harsh criticism by citizens who felt overwhelmed by climate protection measures, as well as by environmental activists pressurising for increased measures. GEMS opponents took financial risks when filing suits against the industry, inter alia, the Dutch Ministry for Climate and Economic Affairs (EZK), the Dutch approval authority, and against one German regional authority. They did so because they saw climate and biodiversity protection threatened by a new fossil fuel production site. Island communities and environmental actors placed the spatial extent and seabed properties of the Borkum Reef Ground on the political agenda when aiming to prevent gas extraction by the ONE-Dyas enterprise. A coalition of claimants (hereafter "claimants"), through several litigations in the Netherlands, had provoked a building freeze lasting more than one year. Despite various court cases, some successful and others ongoing, the EZK permitted the start of the GEMS project in July 2024. Drilling began immediately in the Dutch coastal waters. The permit to drill under the German seabed was granted at the regional level thereafter but was pending at the national level due to the need to sign a bilateral agreement over the exploitation of the transboundary seabed (Ittner, 2024).

From the German perspective, the case study examines the Borkum Reef Ground as a sandbank biotope complex (Rachor & Nehmer, 2003, pp. 21, 167; called "complex" hereafter), in which endangered benthic species require protection, contrasted by a view according to which the seabed should serve as a gas extraction site. It analyses how the industry, approval authorities, claimants, and other project opponents seek to deny or produce evidence about stone reefs. It asks what implications for biodiversity protection and ocean governance are derived from administrative fragmentation and knowledge politics by a diverse set of actors.

The study continues with the description of the concepts, which derive from science and technology studies and the sociology of ignorance. In Section 3, the authors present their research methods and describe the case study. The empirical analysis is organised as follows: Section 4.1 explains challenges in detection and the legal categorisation of stone reefs, Section 4.2 highlights governance outcomes of administrative fragmentation, and Sections 5.1 and 5.2 analyse the production of counter-knowledge and knowledge politics in the context of the GEMS litigation. Section 6 discusses knowledge production and ignorance in the context of industrial projects taking into account the evidence of the case study. Section 7 provides conclusions.

2. Conceptual Approach

Scholarship of environmental contestations emphasises the relevance of scientific knowledge and the production of "unofficial," bottom-up counter-knowledge and studies the role of different types of knowledge in legal contestations over nature. Comparing shale gas contestations in European countries, for instance, Cantoni (2022, p. 350) underlines the fact that "in many environmental disputes the only factor influencing the outcome is the ability to produce knowledge." While "official" knowledge is produced by, for example, universities, research institutes, think tanks, and research units of public administrations, the origin of "unofficial" counter-knowledge is manifold. It includes specialised staff of civil society organisations and consultancies, lay experts, or local communities. Information exchange among various opponents across national borders can be central here. With regard to shale gas contestations in Europe, it allowed the evolution of a "genuinely transnational, science-based anti-fracking movement" (Cantoni, 2022, p. 351).

Derived from a review of 77 studies on contested pipeline projects, Hess et al. (2023, p. 7) found that litigation was one effective, institutional tactic which, as "an accumulation of small victories [,] can slow-down the approval process and result in a no-build outcome." Litigation, however, required considerable technical and legal knowledge and resources. Opponent coalitions needed to first weigh up potential risks and possible gains and then to prepare a convincing argument of evidence.

Based on a review of studies on science–policy interaction around the cockle fishery and gas exploration controversies during the 2000s in the Netherlands, Floor et al. (2013) investigated the roles of natural scientists in various fora, including courts. Knowledge about the ecological effects of these uses was essential for ocean governance though other variables, such as power relations and economic interest, also played an important role. The legitimacy of scientific knowledge became contested when stakeholders, including gas opponents, politically engaged scientists, and government staff, strategically used the available knowledge. The independence of the scientific knowledge-producing process was questioned. Who commissioned research for what purpose, and who carried out the research, thus became political. The authors emphasised: "Different interpretations of knowledge explain why producing more scientific knowledge is insufficient in finding consensus between stakeholders" (Floor et al., 2013, p. 174).

In the present case study, we assess a similar interplay of knowledge production (as well as different types of knowledge) by diverse actor groups and the use of these different types of knowledge as epistemic and political resources in court rulings over nature. For analysing the case, we consequently draw conceptual inspiration from science and technology studies and the sociology of ignorance (see Wehling, 2021, for an overview of the latter).

Lachenmann (1994), for instance, points to the systematic production of "non-knowledge" or different degrees of uncertainty and ignorance in contestations over using and working with nature. These "systems of non-knowledge" (in German, *Systeme des Nichtwissens*), also referred to as "systems of ignorance," have in common that certain types of knowledge and their representatives are systematically either excluded or delegitimised in decision-making processes. More recent discussions speak of "knowledge certainty" or "clarity" (Senanayake & King, 2021) as forms of knowing that differ from "uncertainty" and "ignorance" (Birkenholtz & Simon, 2022). Yet these recent reflections increasingly underline the non-binary relationship between knowledge, uncertainty, and ignorance (Birkenholtz & Simon, 2022), as well as risk and ambiguity

(Scoones & Stirling, 2020; Stirling, 2010). The authors empirically show the co-existence and parallel use of knowledge and "non-knowledges" or forms of ignorance, partly to strategically master situations of uncertainty or deliberately uphold forms of ambiguity, depending on the political arenas in which the actors find themselves. While, as Proctor (2008, p. 1) rightly points out we "know a lot about knowledge," the study of uncertainties and ignorance is less pursued. We are referring to all types of (not-)knowing and political strategising that are just as relevant in understanding decision-making over how we govern nature, inter alia, the Borkum Reef Ground. We assess this production of ambiguity, uncertainty, and ignorance that makes informed court rulings nearly impossible with a focus on the interactions of epistemic practices (or practices of knowing) and litigations structured by institutional settings (Hornidge et al., 2020). In particular, we draw on the concepts of "undone science" and "unseen science" (see Table 1) that Hess (2020) and Wehling (2021) have developed at the intersection of science and technology studies and social movement studies.

Table 1. Basic concepts of the sociology of ignorance.

Undone science	Unseen science
Social movements/NGOs conduct research in understudied fields, with substantial potential for societal reform processes:	Circulation of scientific knowledge across social fields/arenas reduces visibility:
Epistemic form: scientific habitus defines which problems can be researched and which not	**"Forbidden" knowledge**: politically sensitive knowledge and knowledge that stands against the vested interests of larger (i.e., industrial) lobby groups
Controversial science: for example, difficulty in translating science in policy action. This is a new problem area with little research yet	**Strategic science translation:** translation of knowledge across various social arenas
Undone: contrarian and substantially better financed (private and/or public) research stirs public controversy and systematic forms of delegitimising the civil society-based, self-funded research	**Unseen**: political pressures lead to a systematic self-censorship by researchers who do not want to get entangled in political controversies

The concept of "undone science" focuses on fields of (non-)knowledge in which the qualitative and quantitative lack of knowledge in a given field means that the status quo in society (including the division of power between social groups) is maintained and strengthened. Public or industrial investments in these fields of research are usually not (or only marginally) given. Research financed and conducted by NGOs or other civil society groups remains shallow and can easily be contested in larger public debate. Examples include research on the interactions of science–technology–environment, for example, regarding the risks of nuclear energy production, genetically modified organisms, or certain applications of artificial intelligence. Here, scholars such as Hess (2020) and Frickel et al. (2010) stress that the "structured absence" of knowledge and expertise springs from unequal power positions of reformers and social movement leaders on the one side and industrial and political leaders on the other (Hess, 2016). This allows for a systematic "undoing of science." The concept of "unseen science" builds further on this, but places the emphasis more on making science "unseen" through processes of (deliberate) sequestering or not sharing data, for example, on the health impacts of certain drugs, as well as processes of self-censorship among the individual researchers involved, due to hierarchised, possibly authoritarian, systems of knowledge (Frickel, 2014).

3. Accompanying Research and Case Study

3.1. Data Collection and Analysis

The data collection by the first author (February 2022 to July 2024) began with the analysis of literature, project documents, maps, media, and campaigning material. It builds on semi-structured interviews and informal talks with environmental activists and organisations, staff of public authorities, and a marine geologist from the research project. Quotations from German interview transcriptions were translated into English. Impressions from participant observation and stakeholder engagement were recorded in research diaries. A timeline on gas extraction, and resistance to it in Germany and the Netherlands (1960–2024), and an exhibition were co-produced with GEMS stakeholders.

The position of the first author was comparable to that of the claimants. She had to familiarise herself with marine ecology, the research community, and their language and data sources, to learn about gas extraction, assess GEMS project documentation, and establish contact with experts in natural sciences and public authorities. As she had access to scientific events and networks closed to the claimants, she forwarded relevant information to them and documented their uptake. She accompanied them and documented the GEMS approval process since January 2023. Content analysis and discourse analysis of secondary data, notes, and interview transcriptions were complemented with a spatial-temporal analysis of the chronology of events. A project colleague supported mapping.

3.2. The Case Study: The Contested Description of a Seabed Habitat

The Borkum Reef Ground covers an area of 1.225 km^2 (Álvarez et al., 2019) in the territorial waters and the exclusive economic zones (EEZs). A part of the seabed habitat complex is protected in Germany and a larger Dutch area was recently placed under protection (see Figure 1). European flat oysters contributed reef structures to the complex before it became extinct in Dutch and German waters. Its reefs are restored on both sides of the border (Bos et al., 2023; Pogoda et al., 2023). The habitat complex is thus unprotected, protected, and restored at the same time.

Dutch scientists emphasise the need to document "the last remnants of a once more extensive [oyster] reef community in the North Sea." They found that "the reported area [in historical accounts] varies broadly and often lacks mention of reefs west of the German-Dutch border" (Coolen et al., 2015, p. 85). Scholars in the Netherlands assume a triangular shape of Borkumse Stenen, based on Lindeboom et al. (2005), which ends at the national border, while scholars in Germany usually refer to the MPA limits. The geological description highlights the unity of the area but questions the term "reef":

> Geologically seen, this is a continuous system consisting of post-glacial drainage channels. When looking at the topography of nautical charts, you recognise ridges hinting in a northwest-southeastern direction along the complete East Frisian coast. These deep lines practically lie in a zigzag, which characterises these reefs, the so-called tongue reefs. That's the technical term. It is not a *real* reef in the geological sense. These stone ridges are covered with sand. Sometimes, they look out, sometimes, they don't. Because sanders are also mobile, stone ridges are uncovered or covered. (academic geologist, personal communication, July 31, 2024, emphasis added)
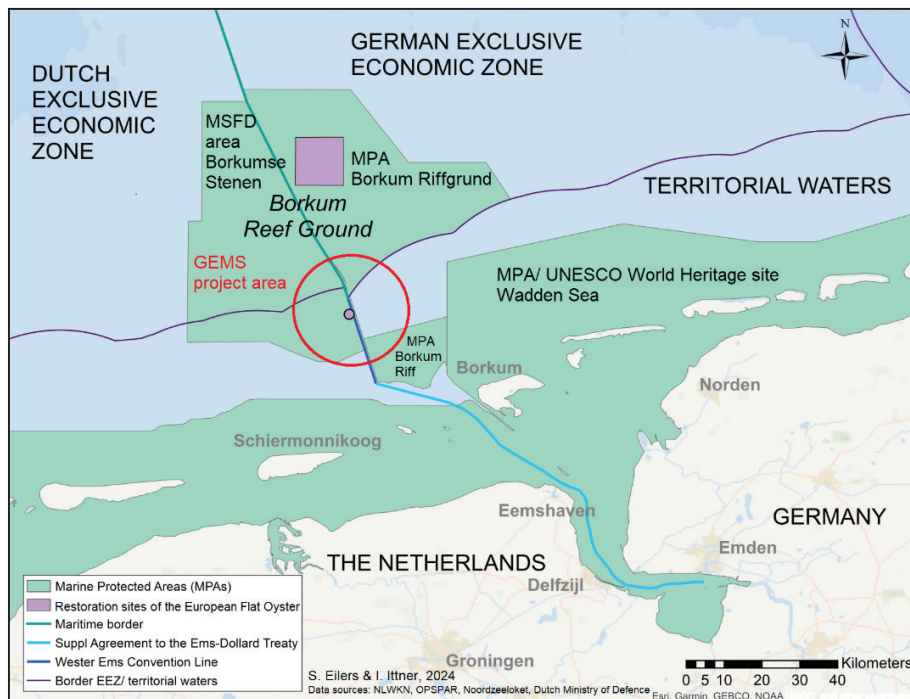
Figure 1. Location of the Borkum Reef Ground. Note: MSFD stands for Marine Strategy Framework Directive.

In the Netherlands, the complex is located in shallow waters, where the seabed consists of hard substrates in the form of cobbles, pebbles, and large stones. On top of this lie sand and gravel, resulting in multiple spatial niches and habitat types accommodating diverse benthic communities. Sandbanks are prevalent in some parts (Álvarez et al., 2019). In Germany, the complex is a large sandbank of 18–33 m depth with interspersed stone fields (Bundesamt für Naturschutz [BfN], 2017). The Federal Agency of Nature Protection (BfN) argued that the Borkum Reef Ground was special due to its close intersection of habitat types defined by the EU—sandbank and reef, as well as the biotopes of gravel, coarse sand, and shingle grounds (BfN, 2017, 2020). International and Dutch scientists stressed the peculiarity of the complex as having the second hard bottom seabed in the Dutch North Sea, besides Cleaver Bank, with coarse sediment and large boulders (Álvarez et al., 2019). Most readings of the complex underline the higher biodiversity of benthic communities compared to neighbouring seabed habitats, as well as the peculiarity of biogenetic reefs erected by the sand mason worm and the ross worm. The Borkum Reef Ground also supports endangered fish and mammal species.

The seabed complex is a mosaic of habitats in occasional flow with an approximate contour. The currents influence the temporality to detect stone formations and the opportunity for benthic species to settle on the boulders. Very strong currents may move cobbles over the seabed. Sand movements and changing stone locations may result in newly assembled piles of boulders and cobbles on top of the seafloor, which may evolve into inhabited stone reefs (Michaelis et al., 2019, p. 83). GPS points of these stone reefs do not necessarily indicate permanence.

In the following, we turn to the analysis of empirical evidence by first showing how legal and administrative fragmentation and strategic science translation produce knowledge gaps. Thereafter, we will investigate the production of knowledge, ambiguity, uncertainty, and ignorance by GEMS supporters and opponents.

4. Legal Implications of Fragmented Mapping

4.1. Are Stone Reefs Real Only When They Are Legally Defined Reefs?

The location of the stone reefs was essential for the presentation of evidence in court, as stone reefs in the GEMS project area would eventually stop the construction of the gas platform and cables. ONE-Dyas and the EZK ministry attempted to convince the judges of the low ecological value of the seabed in the project area and the lack of risk by drilling and laying undersea cables. It was easy to claim that there was nothing worthy of protection. The challenging giving of evidence about the reefs was the task of the claimants, who could not rely on a map showing the contour of the Borkum Reef Ground, and the location of stone reefs in the project area. Such a map did not exist. The claimants consulted dozens of maps and studies for the compilation of evidence. Nobody was a marine geologist or ecologist. Nobody was skilled in professional mapping tools or knew about marine scientific repositories at the beginning of the process. The claimants presented points of evidence, which Dutch judges found difficult to follow. One acknowledged geo-based map issued by a public authority or research institute would have been more powerful. While winning the case and getting the dismissal of the first construction permit established in April 2024, the reasons given for the judgment neglected the question of whether stone reefs could be destroyed by the gas project. This is why the claimants appealed in May 2024.

Why was there no comprehensive, "official" map? The answer is administrative fragmentation within Germany and between the two countries. A German consultancy hired by the public authority Niedersächsischer Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz (NLWKN), during the environmental impact assessment (EIA), drew attention to the regulation gap in the EU Code 1170 of the Natura 2000 Interpretation Manual of EU Habitats (BioConsult, 2022). It defined reefs based on the occurrence of hard compact substrata larger than 64 mm (European Commission, 2007). Following the code, the enduring occurrence of benthic communities on the boulders, though typical, was not necessary for its categorisation as a geogenic reef (BfN, 2018, p. 8).

When BfN prepared the designation of the MPA based on the presence of geogenic and biogenic reefs, it faced various legal and other challenges in implementing Natura 2000 in offshore waters, as well as in defining reefs. Boedeker et al. (2006) and Krause et al. (2006) documented details of the long and complex process and decision-making rationale. The authority finally drew up a supplementary mapping guide supported by the project Sedimentkartierung AWZ von Nord- und Ostsee (SedAWZ). In 70 pages, including annexes, BfN, scientists, and private sector experts refined the criteria for minimal reef areas and reef borders in contrast to their environment. The diversity of reef habitats in the southern North Sea clearly informed the document, all of which, according to BfN experts, demanded somewhat different mapping standards. The guide described geogenic reefs as follows:

> The recording and spatial delimitation are based on hydroacoustic geoscientific methods...and include the following criteria and parameters. Criterion 1: The minimum size of individual stones to be digitised is oriented towards the currently smallest detection size for individual objects in the evaluation of side scan sonar data (resulting stone size of approximately 30–50 cm). Such individual stones or blocks are [displayed on maps with] buffer areas with a radius of 75 m. Criterion 2: If the distance between adjacent single stones...or blocks is ≤ 150 m, i.e., if their buffer areas either touch or overlap, these are

combined to form a "stone or block aggregation." Criterion 3: If such a "stone or block aggregation" has at least 21 individual stones…or blocks with an average distance to their nearest neighbour of ≤ 50 m, it forms a geogenic reef of the type "stone field/boulder field." (BfN, 2018, pp. 13–14, translation by the authors).

Despite BfN's obsession with detail, the consultancy criticised the lack of taximetric criteria based on its work requirements within the context of the litigation (BioConsult & Submaris, 2021). Moreover, the validity of the mapping guide is limited to the German EEZ because it was developed as a reference for MPA designation.

The claimants hired the same enterprises for a critical assessment of the project application documents focusing on the habitat around the anticipated gas platform. This report concluded:

> Following the mapping guidelines of the BfN (2018), geogenic reefs of the type "boulder field" are present in the vicinity of the platform location N05a and also in the area of the planned power cable.…Available data from 2019 and 2021 result in a different reef demarcation…the lower number of boulders in the year 2021, it is likely that they are still present in the area but covered by sediment…side scan sonar contacts classified as "objects" in the Appendix are not all boulders.…Since further differentiation is not possible based on the available data, all side scan sonar contacts are classified as "boulder" by precaution. (BioConsult, 2022, pp. 6–7, 18)

The habitat assessment for the GEMS EIA was prepared by the Dutch consultancy Geoxyz and the British consultancy MarineSpace (company of the Environmental Resources Management Group; MarineSpace, 2022a, 2022b). They considered the EU Code 1170 for describing seafloor properties around the planned offshore platform in Dutch waters and found no structures that they categorised as reefs. The gas fields and prospects in Germany are located mainly in territorial waters, also outside BfN authority, where coastal states are sovereign. In Lower Saxony, however, no mapping guide apart from the EU Code 1170 was yet in place. A scientific diver, who investigated seafloor properties for the GEMS opponents, stated: "You can always argue, if you are a gas drilling company, that there is no reef, because what is a *real* reef? Legally, it is a bit difficult (staff of Submaris; Greenpeace, 2023, translation and emphasis by the authors).

In line with the European Flora-Fauna-Habitat (FFH) Directive and according to the German Federal Nature Protection Law (BNatSchG, § 30/2), stone reefs—if legally categorised as such—are protected, even if situated in unprotected areas. Non-categorised reefs legally remain assemblages of stones and are unprotected. The BfN guideline was applied in EIAs for projects outside the EEZ (BioConsult, 2022). This practice has no legal backing because the NLWKN did not declare the validity of the BfN guide in territorial waters despite knowing its relevance for the GEMS application. The government of Lower Saxony stated that authorities were developing a mapping guide (Greenpeace, 2023). Why distinct administrative processes were set up to refine a European regulation for mapping reef habitats in the German North Sea seems beyond common sense, but can be explained by the administrative culture of German federalism. The diversity of mapping guides, including some not mentioned in this text (cf. BioConsult, 2022), was rather confusing for non-experts.

4.2. An Incomplete Schutzgebietskulisse

The German term *Schutzgebietskulisse* describes all protective measures relevant to a particular area in a complementary, enforcing way by drawing on multi-level legal frameworks and laws (Krause et al., 2022). A cross-boundary habitat perspective on the Borkum Reef Ground rather suggests a fragmented *Schutzgebietskulisse* as the Natura 2000 network remained incomplete until recently. Figure 2 gives an overview of knowledge production in the context of science, marine protection, the gas project, and resistance to the gas project.

Before 1992, seafloor research was motivated by either industrial or scientific agendas. This changed with the EU FFH Directive, which triggered "official" knowledge production on the complex in both countries due to the obligation to present ecologically valuable zones to the European Commission. The period of the early 2000s was characterised by data inventories. Germany produced new seabed and taximetric data and analysis. German reports (e.g., Rachor & Nehmer, 2003) refer to the map by Jahrke which, to our knowledge, is the most recent published sediment map (apart from nautical charts) showing the habitat complex irrespective of national borders. Borkumse Stenen, however, was not displayed on the map. The reason is probably that munition and wrecks from World War II located off the Dutch coast prevented data collection at this time (Jahrke, 1956). After portions of Borkum Riffgrund were sonar-scanned, scientific divers combined the ground truthing of sonar data at the seafloor with the collection of taximetric samples, photography, and video in selected parts of the habitat complex.

The identification of potential protected assets resulted in the suggestion of 625 km^2 (about half of the total complex) as a Natura 2000 site and the designation of the MPA Borkum Riffgrund in 2018. The legal framework for protection, conservation, and restoration emphasises seabed properties and benthic communities as well as twain shads, harbour porpoises, grey seals, and seals (NSGBRgV, 2017). Since 2016, measures for oyster restoration have been prepared and are in the process of implementation. The management plan of the MPA followed in 2020. Bottom trawling was excluded in 2023. Then the BfN published rules about the sinking of blocks to create artificial stone reefs in the MPA to support oyster restoration, including suggestions for detailed sediment studies within the MPA (Westphal et al., 2024).

The spatial extent of the complex informed the boundaries of the German MPA in the north and east. To the south, the MPA ends at the EEZ border while it borders the Netherlands in the west—thus indicating the limits of BfN sovereignty. Stone reefs occur at four distinct locations within the MPA (Pogoda et al., 2023, p. 12). A project colleague remembered having mapped boulders for the Natura 2000 area/MPA designation. These maps are available in public repositories (Bundesamt für Seeschifffahrt und Hydrographie [BSH], n.d., 2013). The focus on the MPA, however, resulted in lower data quality in territorial waters:

> There is no comprehensive modern detailed mapping for these coastal areas. That's the problem. What we have are the so-called Figge and Laurer maps. This is a sampling map with relatively large grids generated in the 1980s, which was slightly updated in the early 2010s. Data density refers to km grids, while more recently recorded data show a considerably higher resolution due to sonar data and denser sampling with a focus on the Natura 2000 areas (academic geologist, interview, July 31, 2024).

German *Borkum Riffgrund* (BRG)	Period	Dutch *Borkumse Stenen* (BS)
Sediment studies in the German Bight (Jahrke, 1956)	**1950s**	Munitions near the Dutch coast prevent research
1964 Inauguration of the Geneva Convention of the Continental Shelf (establishment of EEZs)		
1980s Research: Sediment maps (Figge, 1981)		
1992 European Flora–Fauna–Habitat Directive calls for MPAs		
Research for Natura 2000 designation: sonar scans, taximetric sampling, photography, video	**early 2000s**	Indication of approximate limitation/ BS triangle, little data on BS (Lindeboom et al., 2005; Witbaard et al., 2008) NGOs and scholars lobby to include BS in Natura 2000 and OSPAR frameworks
Since 2012 Research by SedAWZ project: sonar scans mainly within the EEZ Update of sediment maps (Laurer et al., 2014) **2014** 625 km² of BRG (in EEZ) = Natura 2000 area **2017** Natura 2000 area = MPA **2018** BfN mapping guide for reefs in EEZ	**2010s**	Research: sonar scans, taximetric sampling, photography, video (Bos et al., 2014; Coolen et al., 2015) **2017** Plan to protect 108 km² of BS = prohibition of bottom-trawling (VIBEG Akkoord) Research by OCEANA: sonar scans, taximetrics sampling, photography, video (Alvarez et al., 2019) Suggestion to Germany to create a transboundary Natura 2000 area (rejected)
Since 2017 Preparation of the application for approval of GEMS gas extraction project by ONE-Dyas		
2019 Public participation in Germany and the Netherlands		
2020 Management Plan for MPA Sediment and seafloor studies within MPA **2020** NLWKN (with NLPVW) commission diving study (report unpublished) **2021** Marine Spatial Plan **2021–2024** DAM-sustainMare research **2023** Bottom-trawling excluded from MPA	**2020s**	**2021** Government designated 653 km² of BS as MSFD area and plans to exclude bottom-trawling from parts of BS until 2023 (not realised), decision about a bird sanctuary until 2025
July 2022 EZK issues first construction permit; start of litigation / unofficial knowledge production by GEMS claimants on coastal parts of BRG		
Claimants commission study (BioConsult, 2022) **2023** Greenpeace commissions diving study (submaris & BioConsult, 2023) **May 2023** Greenpeace enforces publication of NLWKN study (BioConsult & submaris, 2021) Greenpeace releases a transboundary map and diving study (submaris & BioConsult, 2023)		
September 2023 Claimants present evidence about stone reefs in court		
2024 BfN develops methodology for site selection and sinking of stones to create artificial stone reefs **July 2024** Exhibition "The Reefs off Borkum" co-produced by first author and claimants **September 2024** Greenpeace detects additional stone reefs in the project area		**July 2024** ONE-Dyas starts construction of gas platform in the North Sea

Abbreviations: OSPAR – Convention for the Protection of the Marine Environment of the North East Atlantic, VIBEG – Visserij in Bescherming Gebieden (Dutch agreement on fishery in protected areas), MSFD – Marine Strategy Framework Directive of the European Union, NLPVW – Administration of the Lower Saxony Wadden Sea National Park

Figure 2. Chronology of knowledge production and protection in the Borkum Reef Ground habitat complex.

The German Marine Spatial Plan excludes territorial waters due to there being different public authorities in charge. Within the MPA Borkum Reef Ground, the plan prioritises marine protection but reserves more than half of the MPA area for the hydrocarbon industry and pipelines/cables (BSH, 2022) because valid exploration licences granted by the coastal state authority Landesamt für Bergbau und Geologie were considered. Consequently, BfN anticipated gas projects in the MPA (BfN, 2020).

MPA regulations prohibit the exploration and extraction of resources but allow for exemptions if an overriding public interest is to be safeguarded, if no alternatives exist and when a threat to protected assets can be ruled out (BfN, 2020). German Federal Nature Protection Law provides another back door to the industry because the law must not prevent the realisation of projects of overriding public interest. In the event of an application for an exception, the Federal Nature Conservation Act guides approval decisions. Under current political conditions, marine gas is not an overriding public interest. The GEMS application, however, sets a precedent for gas drillings affecting German MPAs.

In the Netherlands, Natura 2000 research focused on the Cleaver Bank seabed habitat. Borkumse Stenen were not pushed to the forefront because there was little and outdated data available (Lindeboom et al., 2005). New data collection began in the 2010s (Bos et al., 2014; Coolen et al., 2015). Uses in Borkumse Stenen include gas and sand extraction, telecommunication cables, fishery, and shipping (Álvarez et al., 2019). Since 2005, Dutch scientists and European environmentalists suggested the integration of Borkumse Stenen into the Natura 2000 network and OSPAR protection framework (Hugenholtz, 2008). This and later initiatives (Álvarez et al., 2019) faced political opposition in the Netherlands after the seafloor of Cleaver Bank became protected under the EU Habitat Directive.

Dutch policy documents considered Borkumse Stenen as a potential protected area without taking further steps in this direction. In 2017, Dutch authorities intended to place a part of it (108 km^2) under protection as compensation for crab fishing in the Dutch MPA Noordzeekustzone (Álvarez et al., 2019). The Dutch government envisioned the designation of a Marine Strategy Framework Directive area (653 km^3), and the exclusion of bottom trawling until 2023, which indicates the will to protect benthic species, while underlining the intention to exploit all domestic gas fields in the North Sea. Gas is an overriding public interest. Until 2025, investigations will evaluate whether Borkumse Stenen will qualify as a special protected area under the EU Birds Directive (Government of the Netherlands, 2022, p. 101).

5. The Production of Counter-Knowledge and Strategic Science Translation

5.1. Preparing the Arguments for Evidence

The production of "unofficial" knowledge gained first momentum at the end of the 2010s when ONE-Dyas hired consultants to compile information and data for the application for project approval. ONE-Dyas submitted extensive documentation about GEMS to Dutch and German approval authorities, including technical descriptions, maps, legal contextualisation, and expected environmental implications. Most of them are publicly available. These documents provided the knowledge baseline for further assessment. ONE-Dyas was initially very open to communication with claimants, decision-makers, public media, and researchers. This changed during the process of the litigations, which significantly delayed the start of the construction and resulted in high financial losses. The company developed and successfully spread counter-narratives to the arguments of the GEMS opponents (Ittner, 2024)

In 2019, during the public participation in Germany, environmental experts, organisations, municipalities, and individuals submitted more than 400 counter-knowledge reports, mostly anticipating negative environmental impacts. The reports were documented by the Landesamt für Bergbau und Geologie. In 2022, the second momentum occurred after the EZK issued the first construction permit and civil society actors prepared the argument for evidence in court to hinder the construction. A coalition made up of Bürgerinitiative Saubere Luft Ostfriesland, Mobilisation for the Environment, Environmental Action Germany (DUH), and the island communities of Borkum and Juist filed lawsuits in The Hague.

Opponents and later claimants assessed the project documentation by ONE-Dyas and screened it for errors and missing data, especially on pollutants, emissions, noise, and the probability of hazards. The Landesamt für Bergbau und Geologie forwarded their findings to the EZK, who asked ONE-Dyas for corrections and technical improvements. Soon the question of stone reefs in the project area arose. Finding data on their location and pollutant–benthos interactions turned out to be problematic, as the environmental officer of Borkum remembered:

> There was this section between Riffgat [the offshore wind park planned to provide electricity to the gas platform], where the cable is laid….I wrote to the BfN at the time to see whether there was anything [a stone reef]. Because it is strange. In the north is Natura 2000 [MPA Borkum Riffgrund]. In the south is Natura 2000 [MPA Borkum Riff]. Borkumse Stenen lies to the east. Why didn't they connect the two [MPAs]? Because Natura 2000 tells us to create corridors to allow for connectivity. Then I [the authority] just leave a very small strip like this [unprotected]? Why? Funnily enough, we once put this [image] over the map and really hit the spot where this reef was. I asked what it looks like. Is there anything worth protecting? Why hasn't it been put under protection? Then I got the answer [by BfN]: "We are not responsible [for territorial waters]." In addition: "if there was a reef, then, of course, it would be protected." However, it was along the lines of "we do not know anything." Now the study [commissioned by NLWKN, see section 5.2.] has revealed that reefs have been reported to them [the BfN] since 2019 [actually 2020]. That there is one [a stone reef]. That there were investigations. (Borkum Municipal Administration, personal communication, May 17, 2023)

To clarify the situation, the DUH used its right to information and formally requested the full documentation of the administrative process, including MPA planning documents and letters, from the NLWKN. The DUH analysis indicated that Dutch authorities had suggested a transboundary MPA under the Natura 2000 framework, which was rejected because applications for the German Natura 2000 site had already been submitted to the European Commission (DUH, personal communication, November 23, 2023).

While finding their way through the maze of public responsibilities, claimants continued to pose their questions during stakeholder workshops on the author's marine research project. Hiring private experts was costly and challenging due to the limited number of marine consultancies. Some enterprises already worked either for ONE-Dyas, against other industrial projects, or on behalf of BfN. Others aimed to avoid being seen as pro- or counter-industry because this would damage their business model. While members of the coalition suggested an enterprise, other members said that hiring their expertise would be implausible because the same enterprise had supported the industry in a previous litigation. Approaching marine scientists at universities also did not offer the expected insights:

I wrote to so many universities in Germany, including various faculties. I hardly ever received a reply…someone might say I cannot make a statement or something. I am sorry. However, no feedback. Nothing received. I have sometimes asked about publications.…Sometimes I did not even mention the words "gas extraction." We did not get anything. That is disappointing. (Borkum Municipal Administration, interview, May 17, 2023)

I have the impression that there is not so much expertise in gas drilling, especially offshore. We have also approached other research institutes. I just have the impression that a lot of the expertise is with the industry itself.…If the oil companies reported, we would like to have it checked again by an independent institution. But if all people who are familiar with oil and gas drilling, who have studied it, work in the industry…and nobody leaves [this job] and uses this knowledge to carry out research that might shed light on the risks, it is also difficult. (DUH, personal communication, November 23, 2023)

There is one specific field of research where we have often reached our limits…the chemicals discharged into the sea from the gas-drilling platform…how high are the levels of mercury and radioactivity? We have comparative data, but unfortunately, it is only from land drilling. They show high levels of mercury discharges, which also shows that there is a lot of radioactivity. ONE-Dyas installed a carbon-activated charcoal filter in the discharge pipes. At least they say so. They say that almost no mercury gets in [to the sea]. However, there is a ban on the discharge of mercury. Every drop that gets in there is banned.…We are still in the process of gathering information. However, we do not have such a good overview of data, on comparable wells. (DUH, interview, November 23, 2023)

Despite various public data repositories, it was difficult for non-experts to access the relevant scientific findings and knowledge products. It would have needed a guiding hand from marine experts to identify the relevant repositories, studies, and maps. We observed their neglect to clarify technical questions in the context of litigation, which turned out to be a crucial decision-making forum in the user conflict. Their science and their expertise became unseen during the litigation. The denial of support by marine researchers is incomprehensible, as the support provided under scientific principles is always open-ended. Scientists at public institutions would need a new understanding of their role, and perhaps an explicit official mandate to offer their expertise in contested political arenas.

5.2. How to Become a Knowledgeable but Neutral Mediator in the Political Arena

Greenpeace did not join the coalition of claimants but initially pursued an independent anti-GEMS protest. They strategised ambiguity, made an "unseen" study visible, and created "unofficial" counter-knowledge to fill knowledge gaps by "undone" high-quality sediment mapping in territorial waters. After the first court decision on the building freeze in April 2023, Greenpeace acknowledged on its website that the claimants had succeeded. The text neither claimed that Greenpeace was part of the coalition nor clearly stated that it was not—leaving some room for interpretation from the side of the readers. The claimants were not quite sure of what was happening within Greenpeace:

Greenpeace, they don't say anything, do they? They keep very tight-lipped, even among themselves…one does not know what the other is doing under certain circumstances. Depending on what they are working on, they have a very specific information policy.…It is also very centrally

controlled....I think they just do not want things to be published beforehand. (BI, personal communication, May 23, 2023)

In May 2023, about 40 Greenpeace activists climbed onto the roof of the parliament of Lower Saxony demanding the delivery of an unpublished study. The NLWKN and the administration of the Lower Saxony Wadden Sea National Park (NLPVW, both under the authority of the environmental ministry of Lower Saxony) recognised the lower quality of sediment mapping in their coastal waters. They commissioned research in territorial waters, where they suspected a stone reef. In 2020, the coastal research unit of NLWKN and private scientific divers explored a seabed area of two hectares situated 10 sea miles northwest of Borkum Island. NLWKN hired a private consultancy for taximetric analysis. The environmental ministry of Lower Saxony supported the research. The joint report and documentary film, delivered to the NLWKN in February 2021, reasoned as follows:

> The short film was primarily intended for public relations work and the external presentation of this special habitat at public appearances of the NLWKN and the Lower Saxony Wadden Sea National Park and therefore shows the fauna of the reef in beautiful, format-filling shots. (BioConsult & Submaris, 2021, p. 21, translation by authors)

And yet, publication plans seem to have changed. The report and documentary remained unpublished until 2023, respectively 2024. Their content and informal discussions with NLWKN staff, however, did not indicate any intent for non-publication— on the contrary (NLWKN & NLPVW, 2024).

When the NLWKN did not respond to the request by Greenpeace, despite the right to information, the organisation claimed that the study was intentionally hidden because of GEMS. At this time, Greenpeace had already employed the same enterprises to dive at four locations to document stone reefs, including at the site previously investigated for the NLWKN (Submaris & BioConsult, 2023):

> A previously *secret* report from 2021 on rocky reefs off the coast of Borkum that are worthy of protection is bringing new wind into the approval process for the controversial gas drilling in the North Sea—and putting the state government of Lower Saxony in a tight spot. Greenpeace has now carried out its own dives and is contributing additional findings about the magical underwater world near the planned drilling sites. (Greenpeace, 2023, translation and emphasis by the authors)

> Because [Greenpeace] made their request [to NLWKN] they did not get the article. It was actually necessary to literally climb onto the roof of parliament to get the [study]. [Greenpeace] applied for it with a deadline and everything. It is the law. They didn't get it....Scandal....It was only because of this public pressure that [the study] actually came out. (Bürgerinitiative Saubere Luft Ostfriesland, interview, May 13, 2023)

The new government of Lower Saxony claimed to not have been informed about the study. The new environmental minister released it after gaining access to it on its premises (Greenpeace, 2023). The documentary film was finally presented to environmental organisations in 2024. The text of the YouTube post from August 2024 talks about one *recently discovered* reef off the coast of Borkum, which reveals a diverse, fascinating world of flora and fauna (NLWKN & NLPVW, 2024)

To gain expert and insider knowledge, Greenpeace also engaged in background research, commissioned investigations on political dynamics and legal conditions (Horenburg & Verheyden, 2023) and conducted a drifter study to visualise the risk of industrial pollution. Starting from May 2023, after the claimants succeeded in provoking the building freeze, Greenpeace published information in short sequences, starting with a legal opinion piece and another diving and taximetric study on stone reefs in the GEMS project area (Submaris & BioConsult, 2023), while the claimants unsuccessfully tried to hire the same enterprises for support in the litigation. Later, the organisation established itself as a knowledgeable but "neutral" mediator between the NLWKN and the environmental ministry of Lower Saxony (Bürgerinitiative Saubere Luft Ostfriesland, informal conversation). This was possible because they were no claimants.

The claimants gladly embraced the counter-knowledge published by Greenpeace and the enforced publication of the NLWKN study. While Greenpeace's reports supported their argument of evidence, beautiful underwater photography (Figure 3), a podcast, and an interactive map helped to mobilise additional protesters and draw media attention. Information exchange and close cooperation between the claimants and Greenpeace Germany began before the court hearing in January 2024.
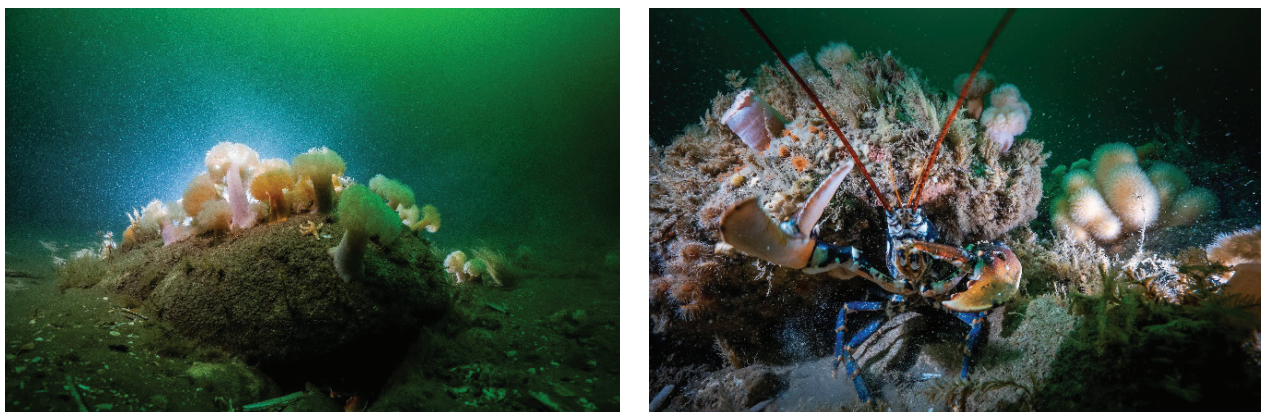
Figure 3. Stone reef in German territorial waters. Note: These photographs were taken by Uli Kunz of Submaris. Source: Greenpeace (2023).

The map was emphasised in some reports. It was difficult to trace it on the Greenpeace website on other occasions. It was interactive at times and static at others, not providing a reliable source of information to other activists. In court, ONE-Dyas claimed that Greenpeace had not granted access to the spatial data on newly detected stone reefs upon request. Greenpeace responded that data were published openly on their website. They had also informed the respective public authorities (Greenpeace, 2023).

The marine natural research community completely missed opportunities for transdisciplinary co-production of knowledge in the context of the German approval procedure and litigations, partly because of ignorance and partly due to the wish not to engage in contested political areas. They remained distant observers, cutting them out of ongoing knowledge production by the GEMS opponents and the political processes.

6. Discussion

Knowledge fragmentation about the transboundary habitat complex began in 1964, which also earmarked national sovereignty over marine knowledge production, planning, and management. Industrial and scientific

interest informed research in the subsequent decades. The EU FFH Directive first encouraged and later pressured the countries to suggest marine sites as Natura 2000 areas. Authorities set pragmatic research priorities to come to relatively quick and affordable suggestions. Germany prioritised parts of Borkum Riffgrund situated in the EEZ and neglected part of the habitat in territorial waters. The Netherlands prioritised Cleaver Bank, which also had a hard substrate seafloor, and initially neglected Borkumse Stenen. Since 2012, sediment mapping in Germany focused on the EEZ (SedAWZ project). Later adjustments and unification of data qualities remained a challenge in fragmented marine governance settings (Heinicke et al., 2024). The article illustrates how national divisions, and prioritised knowledge production about seabed properties, first led to a gradual shift in its perception as a transboundary seabed habitat complex to two distinct national marine areas.

Secondly, many years later, during the approval procedure for an industrial project, the industrial enterprise, German authorities and project opponents faced insufficient documentation of seabed properties in the project area, which they were unable to close by their own means. The potential for an ad hoc, applicable production of knowledge at sea was limited because of a lack of resources. The actors had either no access to ships able to perform comprehensive seafloor detection, shipping time, and permissions (valid for two countries), considerable funds, expertise, or—importantly in the context of the litigation—sufficient time, although the latter is debatable, considering the public authorities. None of the actors had all these resources to provide new baseline data for decision-making. Of course, there were different stakes as well. The "undone science" in the form of low-resolution sediment maps was not intentionally produced. It was caused by initial pragmatic approaches and future neglect of "unpurposeful" research, which was not applicable in the context of marine protection schemes. Of course, the authorities could have anticipated future EIAs for industrial projects in non-protected areas and taken timely action.

The counter-knowledge about reef locations supported the mobilisation of opponents. It convinced neither judges nor authorities because the evidence was patchy, not based on scientific standards, and did not originate from "official" knowledge sources. "Official" marine geology in Germany and the Netherlands was limited by national borders, determination by research proposals, extensive administration for shipping trips, and the focus on MPAs in Germany. It could not respond in a timely fashion to knowledge needs in the context of the litigations. Perhaps the production of counter-knowledge and the translation of knowledge to other social fields, such as the legal field, are especially challenging in the context of transboundary marine industrial projects because of highly specialised knowledge, costly research logistics, and administrative hurdles.

The example of stone reefs underlines the fact that marine protection and ocean governance rely on definitions and criteria by "official" ocean governance actors to be legitimate and legally sound, even if these, like in the BfN mapping guide, were co-produced by an authority, scientists, and private sector consultancies. Besides providing transparency and clarity to experts, regulation may entail ambiguity related to the question of validity in other administrative areas. Over-regulation and parallel regulation for different administrative areas resulted in the disorientation of non-experts, and therefore in the lack of transparency of ocean governance rules to civil society.

The study has illustrated how knowledge about the material manifestation of the biodiversity hotspots did not enter the shaping of regulations, inter alia, remained a legal uncertainty. A revealing aspect is also that the lack

of regulation at the coastal state level practically cancelled out national and European protection measures, although the sub-national level is subordinate to the latter two.

Another issue is remarkable. While project opponents invested substantial time and private money to clarify seafloor conditions in order to prevent a fossil fuel project and the loss of benthic biodiversity in territorial waters, the BfN invested public money in rule-making and the preparation of the sinking of artificial reefs in the MPA to support oyster restoration. This required more detailed seabed studies to identify suitable sinking spots. Obviously, marine research and protection were organised along the lines of administrative and MPA logic and did not fully consider marine habitats.

7. Conclusion

We identified four motivations for marine knowledge production: scientific interest, industrial stakes, knowledge requirements to respond to EU marine protection schemes, and political interest to prevent industrial projects. Knowledge production occurred in waves related to upcoming stakes. Under conditions of accelerating industrialisation, the quality of available knowledge and knowledge products for unprotected areas gain relevance, as does the flexibility of public science and authorities to respond to knowledge needs in order to support approval decisions. As such, the portrayed analysis sensitises for "unseen" and "undone science" and for giving nature some rights. High-resolution mapping of industrial zones will play a crucial role in this, as well as data on accumulative pollution.

Contemporary marine science has all the technical measures at hand to detect detailed seabed properties and the distribution of benthic taxa (Beermann et al., 2023; Michaelis et al., 2019) but it is elaborate and costly with many administrative requirements, which make transboundary research difficult. One wonders how countries with fewer resources or larger EEZs than Germany and the Netherlands will be able to completely map their EEZs, particularly non-protected areas. The case study has illustrated how the prioritisation of funding for MPA mapping may backfire on knowledge gain in potential industrial zones and, therefore, on overall marine protection.

Conflict of Interests
The authors declare no conflict of interests.

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ARTICLE

Identifying Ocean-Related Literature Using the UN Second World Ocean Assessment Report

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Abstract

In recent years, ocean governance has called for strategic action and science-informed policy to work towards the sustainable development of the ocean, most notably as part of the UN Decade of Ocean Science for Sustainable Development (2021–2030). This common framework identifies the integration of scientific knowledge in governance as a key process to deliver solutions responding to the current challenges, opportunities, and transformations posed by global change in the oceans. This article presents a methodological approach for identifying ocean-related research outputs and documenting research-based knowledge integration in documents that inform ocean governance. Specifically, this study builds on an analysis of the references included in the *UN Second World Ocean Assessment* report to (a) identify and describe the research outputs cited in the distinct chapters of the report, (b) identify research outputs relevant to ocean governance through the analysis of citations from and to references included in the *UN Second World Ocean Assessment* report, (c) compare both datasets to examine the position of the literature cited in the report within a broader ecosystem of ocean-related research, and (d) present a method to identify topically relevant research that could be integrated in future ocean assessments. Our findings show distinct referencing practices across chapters and expert groups and a higher reliance on high-profile sources in the report compared to a broader dataset of ocean research outputs. Moreover, this study highlights an innovative approach to identifying ocean research based on knowledge syntheses and considers discussion points about integrating research-based knowledge in documents informing ocean governance.

Keywords

knowledge mobilization; ocean governance; ocean research; scholarly communication; science-policy interface; scientific knowledge; UN

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1. Introduction

Global ocean governance can be understood as a "holistic, integrated, and/or cross-sectoral approach to the management of the oceans, its resources, and the human activities occurring within it or affecting it" (Molenaar, 2019, p. 419). Recently, the UN Decade of Ocean Science for Sustainable Development (2021–2030) and the UN 2030 Agenda for Sustainable Development provided frameworks to direct the trajectory of ocean governance toward strategic action and science-informed policy (Gerhardinger et al., 2024; UN, 2015; UNESCO, 2017; UNESCO-IOC, 2023). As these frameworks specifically call for the integration of research-based knowledge in ocean governance, they invite to consider the identification of research relevant to ocean governance and examine its integration in documents such as the *Second World Ocean Assessment* (WOAII) report knowledge synthesis (UN, 2021). This study presents a process for the identification of ocean-related research outputs through the analysis of the references included in the WOAII report as a recent and global state of knowledge about oceans dedicated to informing ocean governance.

The integration of scientific knowledge into policy decisions is a key process for delivering evidence-based and actionable solutions (Karcher et al., 2024). Reports such as the WOAII leverage the efforts of hundreds of experts across the globe and effectively create tools for policy and decision-makers to use as credible and authoritative sources (Evans et al., 2021). They also present an opportunity for critical engagement: What knowledge is mobilized in the WOAII and other seminal reports, and what is excluded? How does the literature cited in such assessments compare to the broader existing body of knowledge about oceans? How can we identify relevant research outputs—literature identified by DOIs and indexed in bibliographic databases, including peer-reviewed articles, books, book chapters, datasets, and grey literature—that could inform the development of ocean-related policy and action? This study uses a bibliometric approach to explore the potential of analyzing official assessments to identify ocean-related research outputs, examine the broader field of ocean research, and document the integration of knowledge in documents informing ocean governance. We first present a review of the literature on the WOAII report, the science-policy interface, and the contribution of bibliometrics to capturing ocean research. We then present the methodology used to identify ocean-related research and examine both the set of literature cited in the WOAII report and that included in a broader dataset of documents related to ocean research. We finally describe and compare the datasets, guiding a discussion around the potential of our approach to identify ocean-related research and to examine what research is integrated into documents informing ocean governance.

2. Literature Review

2.1. The WOAII as a Science-Policy Interface

The translation and transfer of information from knowledge generators to decision-makers to society occurs in many forms (Evans et al., 2021). These bridges between the realms of scientific research, governance, and public understanding can be understood as the science-policy interface, encompassing the multiple and complex pathways by which decision-making should be informed by scientific evidence (MacDonald et al., 2016). Interactions at the science-policy interface represent both the mechanisms and interactions through which scientific activities may influence decision-making and governance, and the mechanisms through which policy may, in turn, impact the advancement of scientific knowledge and research priorities. For example, the UN Decade of Ocean Science for Sustainable Development highlights the crucial role that

science should play in informing ocean governance, thus promoting the creation of mechanisms and frameworks to facilitate the production and dissemination of ocean research (McKinley et al., 2023). Scientific information is thus a key vector for ocean governance to address related issues, such as articulating the needs of fisheries and conservation, through evidence-based decision-making (Bogenschneider & Corbett, 2021; Karcher et al., 2024; MacDonald et al., 2016).

Scientists disseminate useful evidence stemming from research to inform decision-making (MacDonald et al., 2016), but there remain questions about the mechanisms by which policymakers access scientific evidence (Wellstead et al., 2018). There are also socio-topical and information retrieval dynamics at play that may favor the inclusion of certain types, topics, and clusters of knowledge in ocean governance (Toupin et al., 2023). Knowledge syntheses, reports, and grey literature typically play an important role at the ocean science-policy interface by synthesizing relevant knowledge into digestible formats that are more readily accessible for decision-making (Cossarini et al., 2014). Nevertheless, divergence has been found between scientists and policymakers regarding their respective roles at the science-policy interface, as well as in broader knowledge mobilization processes ranging from passive knowledge transfer to high levels of engagement, influencing the availability and use of scientific evidence by policymakers (Rudd, 2015). The UN, among other global organizations, supports this interface by producing comprehensive and integrated syntheses of scientific and grey literature through public-facing reports such as the WOAII, a work akin to the reports produced by the Intergovernmental Panel on Climate Change (IPCC) in the case of climate change (IPCC, 2021). These documents provide valuable knowledge brokering of complex, technical topics that are presented in usable, accessible formats and contain information that is at times not directly available to policymakers and the public (Evans et al., 2019, 2021).

2.2. The Production of the WOAII Report

The WOAII report, an integrated assessment of the environmental, economic, and social aspects of the Earth's oceans, was produced through the second cycle of the Regular Process for Global Reporting and Assessment of the State of the Marine Environment, including Socioeconomic Aspects to provide a scientific foundation for policymaking (UN, 2021). Produced by interdisciplinary writing teams comprising 300 authors drawn from a pool of over 780 experts (scientists, policymakers, volunteer experts, and other actors) from across the globe (UN, 2021), the report provides a public and official state of knowledge on ocean matters. The expert teams outlined a report structure informed by a workshop series, the outcomes of the *First World Ocean Assessment*, and regional assessments and priorities (UN, 2021). Members of the writing teams synthesized scientific information on key topics; leads and co-leads of each chapter provided guidance on acceptable types of information and were expected to, as much as possible, rely on the "best available data and information" to produce sound and well-supported conclusions (UN, 2021, p. 44). Information gathering and content development were also informed by wider groups of stakeholders through workshops, dialogue, peer review processes, and input from the member states of the UN (Evans et al., 2021).

The WOAII usefully synthesizes relevant information but is not a comprehensive systematic review of all available ocean literature. Rather, it is a curated document produced through a collaborative yet selective information-gathering process, resulting in a structured report that refers to a limited set of literature that naturally favors certain types of knowledge and may provide uneven topical or regional coverage (Feary et al., 2014; Mendenhall & Helm, 2024; Turnhout, 2024). As Evans et al. (2021, p. 5) state:

Writing teams contributing to both the *First* and *Second World Ocean Assessment* have often been uneven in their disciplinary and regional coverage. An outcome of unbalanced contributions to writing teams is that chapters have varied in their scope, the degree to which they have covered the diverse range of topics and the extent to which complex scientific information was integrated across disciplines and delivered.

This study uses the WOAII report as an entry point to identify a broader body of ocean research literature, thus taking an opportunity to develop a method to document the field of ocean research and examine the integration of research outputs in ocean governance. This case study contributes, on the one hand, to the development of new bibliometric approaches to capture research outputs about socially relevant issues, and, on the other hand, provides an empirical assessment of the knowledge integrated into an official document informing ocean governance.

2.3. Capturing and Analyzing Oceans Research

Following a recent shift in bibliometric studies to investigate the dissemination of research outputs outside of academia, many studies have explored methods to identify research outputs about socially relevant topics, such as ocean affairs or Sustainable Development Goals (SDGs). For instance, Kashnitsky et al. (2024) assessed extant approaches to mapping literature to the SDGs and found most involved Boolean methods. Among other studies that aimed to map literature about SDGs, Armitage et al. (2020) also compared bibliometric approaches to better map research outputs to corresponding goals, while Purnell (2022) examined methods specifically identifying literature related to SDG13 "climate action." Methods based on large language models and search queries were also developed by Bergeron et al. (2023) and Bordignon (2021). However, both machine learning and query-based approaches pose challenges around diverse understandings of topics, search precision and accuracy, and interpretations of the results of automated processes (Kashnitsky et al., 2024).

More closely related to ocean-related literature, Lercari (2021) analyzed marine science research institutionally affiliated with Uruguay, using Scopus, to provide insights on publication trends, research topics, and collaboration. Picone et al. (2021) conducted a bibliometric analysis of Marine Protected Areas research retrieved from Scopus and Web of Science to show a temporal evolution of its conceptual focus. In another study focusing on rhodolith bed research, Rendina et al. (2022) recognized that using Scopus for a bibliometric assessment excluded grey literature on the topics. More recently, Potter and Pearson (2023) analyzed ocean basin research trends and collaboration patterns using a title-abstract approach rather than relying on Web of Science subject categories. In another approach, 169 SDG queries were developed by Vanderfeesten et al. (2020) to identify relevant research outputs, while Guyot-Téphany et al. (2024) conducted a bibliometric analysis on multi-use ocean research using Scopus to create a corpus that then underwent manual review. Toupin et al. (2023) used citation analysis to identify and document shark-related research clusters and examine the distribution of citations, tweets, media, and policy mentions, while Costa and Caldeira (2018) conducted a similar analysis about the concept of ocean literacy. Finally, Lübker et al. (2023) performed latent Dirichlet allocation topic modeling on 8,580 cross-disciplinary scientific articles collected through Scopus about the high seas to structure their dataset and discover topical themes in the literature which they used to create narratives. These approaches illustrate the opportunities and challenges arising in the development of methodological frameworks to identify ocean research outputs. Therefore, they inspired the development of the framework presented in this study that focuses on

capturing outputs through the citation links of works referenced by a knowledge synthesis report about ocean matters.

2.4. Purpose of the Study

This article presents both an empirical examination of the literature cited in the WOAII report and a methodological contribution to the identification of ocean research outputs stemming from the citation links to and from the literature mentioned in the report. Both contributions aim to improve our understanding of the integration of research-based knowledge in a document informing ocean governance. Our approach uses the WOAII as a case study to leverage the report's unique structure to locate and capture an expanded set of ocean research literature. We used the WOAII report as it is one of the most recent global knowledge syntheses of ocean-related topics, thus providing foundations to look at a broad body of ocean research. This broader body of literature is then used to describe the references included in the WOAII report and to provide keys for the identification of other relevant ocean research outputs that could contribute to future knowledge synthesis regarding oceans. Our research questions are as follows:

> RQ1: What literature is cited in the WOAII report?
> RQ2: How can we identify research outputs that are or could be integrated into knowledge syntheses informing ocean governance?
> RQ3: How does the literature referenced in the WOAII report compare to a broader dataset of ocean-related research?

This article also provides a proof of concept regarding the use of knowledge assessments published by official bodies, such as the UN and the IPCC, to identify outputs about complex socioenvironmental issues. As an official assessment of the state of oceans, the WOAII provides a window to examine the knowledge integrated into ocean governance, but also to investigate how this knowledge is connected to a broader body of literature about oceans.

3. Methods

3.1. Collecting Works Cited in the WOAII Report

The WOAII report includes two volumes, separated into 28 chapters, with Chapters 6, 7, and 8 further divided into subchapters that were considered separate chapters for data collection, resulting in 51 distinct chapter entries. Excluding Chapter 1 ("Overall Summary") and Chapter 2 ("Approach to the Assessment"), the analysis was conducted on 49 topical chapters written by distinct expert groups. A total of 4,723 references were manually extracted from the report, segmented by chapter, and copied in the UN style into a spreadsheet. For each entry, we added the chapter, volume, chapter title, and document type per the APA reference style. The resulting dataset, separated by chapter, included 3,927 documents with DOIs. All references were sent through the Simple Text Query form at Crossref to obtain DOIs, returning 3,516 unique DOIs. We found 70 more DOIs using a Levenshtein distance title-matching process of OpenAlex data, resulting in 3,586 unique DOIs. Documents without DOIs mostly included reports ($n = 571$), data entries ($n = 70$), websites ($n = 53$), and news pieces ($n = 37$); 96.51% of journal articles had DOIs. Using the DOIs obtained for the core dataset of references in WOAII, the metadata for these works was retrieved from OpenAlex, an open bibliometrics

database offering the largest coverage of research outputs, using custom R scripts and the OpenAlexR library (Aria et al., 2024; Priem et al., 2022). The 3,586 distinct DOIs returned a list of 3,809 total references and 3,532 unique works with metadata present in OpenAlex (hereafter the core dataset).

3.2. Collecting Works Related to the Core Dataset

Records for works either citing or cited by the core dataset were then retrieved, resulting in a list of 419,079 works (hereafter the full dataset), including the core dataset, and 740,613 citation links (citing or cited by) between records in the core and full datasets. Authors were extracted from the records, producing a list of 693,770 distinct authors (based on their OpenAlex IDs), and nearly two million authorship records (links between authors and papers). Datasets built through the course of this study, including the list of all works in the full dataset, WOAII chapter details, core works referenced per chapter, citations, authors, and authorship links, were stored in a PostgreSQL database. The database entity relationship diagram is available in Figure 1 of the Supplementary File, illustrating how information was organized to connect data and metadata relevant to both the core dataset of references included in the report and the full dataset of all documents connected to the references in the report.

3.3. Identifying Ocean Literature

Upon collecting all documents connected to the references included in the report, we developed a process to identify relevant ocean research literature based on five document-level criteria: (1) being cited by or (2) citing a core document, (3) co-authorship links, (4) keywords relevant to the chapter topics of the report, and (5) publication in a journal topically related to oceans. We then checked how well combinations of these criteria contributed to capturing ocean-related research outputs. On a per-chapter basis, the number of incoming citations from the core works (1 Cg [citing core]), the number of outgoing citations to these works (2 Cd [cited by core]), and the number of author co-occurrences (3 Ca [coauthorship relationship]) with the core works from the chapter were calculated for each work in the full set. Multiple papers in the core dataset with a shared author (multiple papers for one author) and individual papers with multiple shared authors (one paper with multiple authors) both contributed to the co-authorship numbers. As part of the identification process, we also identified keywords related to oceans by reading the keynote points of each chapter of the report, resulting in a list of 687 keywords (4 Kw). This list was further cleaned by stemming, removing, and adapting keywords based on the following criteria:

1. Concept is related to the chapter and oceans
2. We favor precise terms (sea ice) vs. generic terms that can generate semantic ambiguity (ice).
3. When a word is ambiguous (e.g., banks) but not generic (it is topical—alternate definitions relate to specific objects or themes), it is included. For example, banks is a topical word as it relates to either marine topography or financial institutions.
4. When a word is ambiguous but also general (not topical; e.g., population, current, and slope), it is excluded.

After cleaning, the resulting list included 232 keywords specific to the oceans and related topics (see Table 1 in the Supplementary File). Though coded on a per-chapter basis, the keywords were used to check for ocean-related research in general. Thus, generic keywords ("ocean," "sea," "marine," and "coast") were added

to the list as well. Finally, going through the list of sources for the full dataset, two authors of this study manually identified 791 journals closely related to ocean research (5 Jo [journal of publication]). At the document level, each criterion was given a present/absent score (either the criteria are present or absent from the document) as part of the identification process. This process resulted in 24 combinations of the five criteria categorizing the works included in the full dataset, excluding those from the core dataset. The list of all document-level combinations can be found in Table 2 of the Supplementary Files.

3.4. Qualitative Assessment of the Performance of the Ocean Literature Identification Process

For each of the 24 combinations of the five criteria used in the identification process, a random sample of 100 works was extracted with only the OpenAlex ID, the title, and the abstract, resulting in a total of 2,384 works. This sample dataset was randomly sorted and manually coded by two coders, without knowledge of the associated combination, to assess the relationship of the documents to oceans and related topics based on the title and abstract. In addition to a direct relationship to oceans (Code 2) and no relationship (Code 0), works could also be indirectly related (Code 1), for example, literature about related issues, such as climate research. A first intercoder reliability test was performed after coding 500 works (Krippendorff's alpha = 0.73; Cohen's kappa = 0.55) and a second one after 800 works (Krippendorff's alpha = 0.75; Cohen's kappa = 0.60) to adjust the coding scheme and come to a better agreement between the two coders (Krippendorff, 2004). The intercoder reliability tests were performed in R using the standard parameters of the test_icr function from the Tidycomm package (Unkel, n.d.). Differences in coding categorization were discussed between tests to improve agreement on the best categorization by the coders. After the series of 800 works, 169 documents with differing categorizations were again recoded separately, and the resulting intercoder reliability test on the updated set of 800 works indicated a strong agreement (Krippendorff's alpha = 0.93; Cohen's kappa = 0.86). Further discussions between the two coders contributed to an agreement on the best categorization for the remaining 60 works still coded differently. The remaining 1,584 works were separated and coded independently by the two coders. The results of the coding process were subsequently matched back to the documents' metadata, including the criteria combination, to compare the performance of the different combinations in capturing ocean-related research. A performance score in identifying ocean-related research was calculated for each combination based on the sum of all individual work classifications divided by the number of works sampled in a specific combination times 50, which gave a score out of 100%. We describe three datasets of ocean-related literature based on the combinations that performed above the performance thresholds of 90%, 75%, and 60%.

4. Results

4.1. What Literature Is Cited in the WOAII Report

Altogether, the WOAII report includes 4,723 references across 51 chapters and subchapters. Among the most cited types of publications in the report, references to journal articles are the most common (n = 3,527), followed by reports (n = 649), books and open educational resources (n = 250), and data and databases (n = 134). Among documents indexed in OpenAlex, the most prevalent type of research literature is the article (works = 3,088; references = 3,338), followed by book chapters (works = 176; references = 181), reviews (works = 93; references = 104), books (works = 58; references = 61), and datasets (works = 58; references = 59). These results indicate that most references to grey literature were

not captured in OpenAlex, reflecting instead research-based types of literature. The document most cited by the WOAII report is its predecessor, the *UN First Global Integrated Marine Assessment: World Ocean Assessment* ($n = 39$). Outside of this, the most cited document is the journal article "Ecosystem Function and Services Provided by the Deep Sea" (Thurber et al., 2014), with 5 references. The 4 most cited journals are *Frontiers in Marine Science* (155 references; 130 distinct documents), *PLOS ONE* (106 references; 94 distinct documents), *Scientific Reports* (100 references; 90 distinct documents), and *Science* (109 references; 79 distinct documents). Except for *Frontiers in Marine Science*, these results indicate a trend toward high-profile multidisciplinary journals to document the knowledge recorded in the report. The document referenced in the report with the most total citations overall, based on the OpenAlex citations count, is the *Summary for Policymakers of the IPCC 5th Assessment Report*, published in 2014, with 12,275 citations at the time of data collection (IPCC, 2014). The mean number of citations for works referenced in the WOAII report is 247 and the median is 72 with a standard deviation of 711.96, indicating a heavily skewed distribution of citations among the references of the report. References cited in the report were published between 1874—a book by Charles Darwin titled *The Structure and Distribution of Coral Reefs* (Darwin, 2013/1874)—and 2021, with about 60% of the works published between 2016 and 2019.

Referencing practices vary significantly between chapters (Figure 1). Excluding Chapters 1 "Overall Summary" ($n = 0$) and 2 "Approach to the Assessment" ($n = 7$), the minimum number of references in a chapter is 17 (Chapter 7A "Intertidal Zone") and the maximum is 225 (Chapter 7J "Continental Slopes and Submarine Canyons") with a mean of 97, a standard deviation of 45.3, and a median of 92 references (Figure 2). These variations are also reflected in the references with DOIs (minimum = 9 for Chapter 17 "Changes in Seaweed Harvesting and Use," maximum = 209 for Chapter 6A "Planktons," mean = 76; standard deviation = 44.4; median = 67) and the references in OpenAlex (minimum = 8 for Chapter 17; maximum = 206 for Chapter 6A; mean = 75; standard deviation = 43.8; median = 65). The proportion of references with open OpenAlex records also varies significantly across chapters, with a maximum of 94.50% for Chapter 6A and a minimum of 20% for Chapter 19 "Changes in Hydrocarbon Exploration and Exploitation." The mean proportion of references included in OpenAlex is 73.86% with a standard deviation of 16.07. In the case of Chapter 19, most citations appear to be made to reports or news documents, which are not typically indexed in OpenAlex. These results reflect the choices made by the various writing groups in selecting the most relevant information for their respective chapters, which may be more oriented toward grey literature and reports for certain topics, compared to research outputs in the case of others. In the case of chapters 6A and 19 for example, the citation choices are dominantly for journal articles in 6A (170 articles; 24 reviews; 15 books; 2 reports; 1 thesis; 8 as other), whereas in 19 reports and websites are preferred (10 articles; 17 websites; 14 reports; 4 magazine articles; 2 books; 1 review; 1 standard). A summary of the descriptive analysis for each chapter is available in Tables 3 and 4 of the Supplementary File.
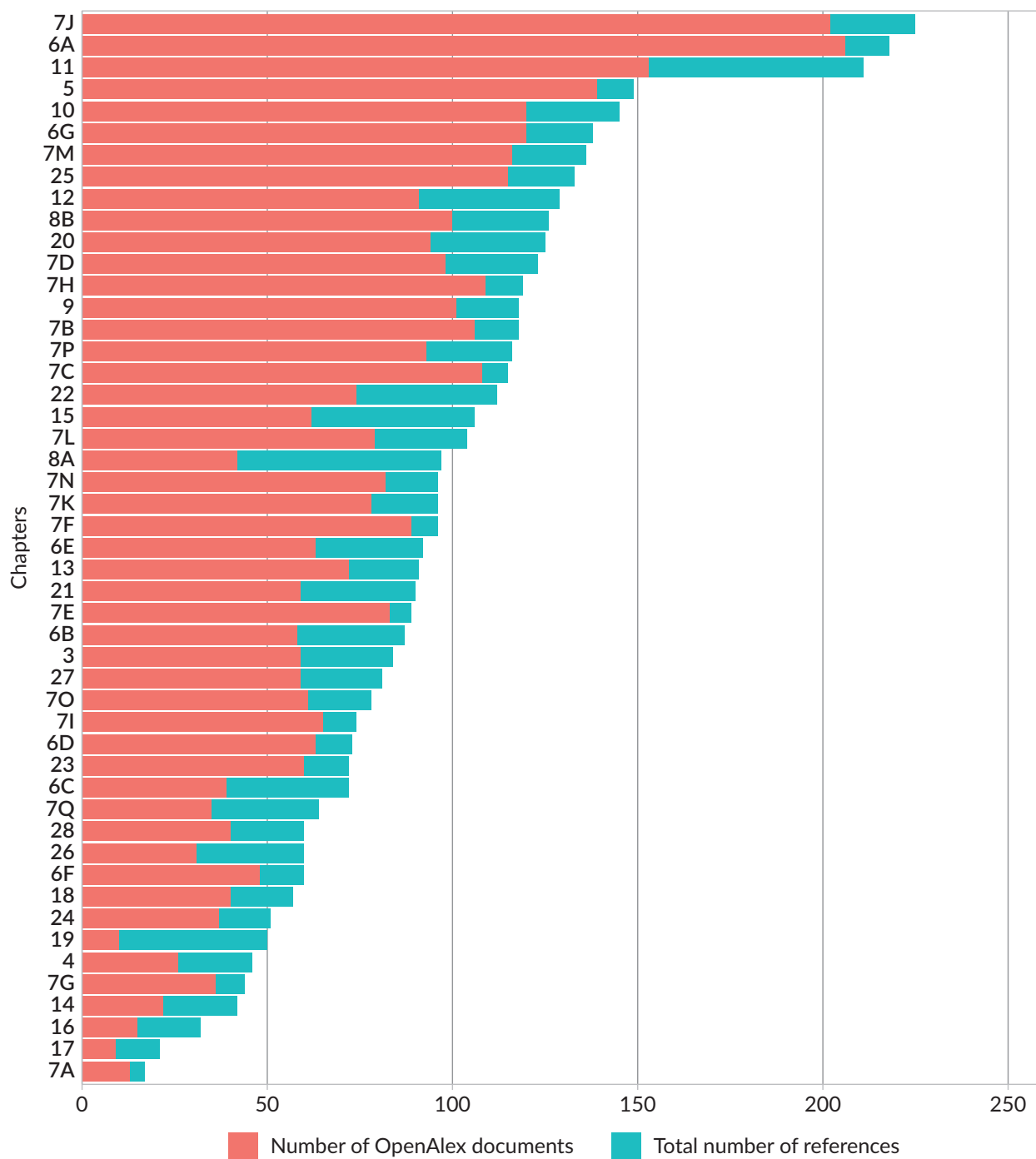
Figure 1. The number of references and OpenAlex documents per chapter entry in the WOAII report.

4.2. The Broader Body of Literature Connected to the WOAII Report

The references included in the core dataset feature 740,613 citation links, resulting in a full dataset of 419,079 documents. Among these, 528 documents of the core dataset are neither citing nor cited by other core documents; 823 are citing; 499 are cited by; and 1,692 are both citing and cited by documents in the core dataset (Figure 2). A total of 304,624 documents have only a citing relationship to documents from the core dataset, whereas 90,475 have only a cited-by relationship. A total of 20,438 documents outside the
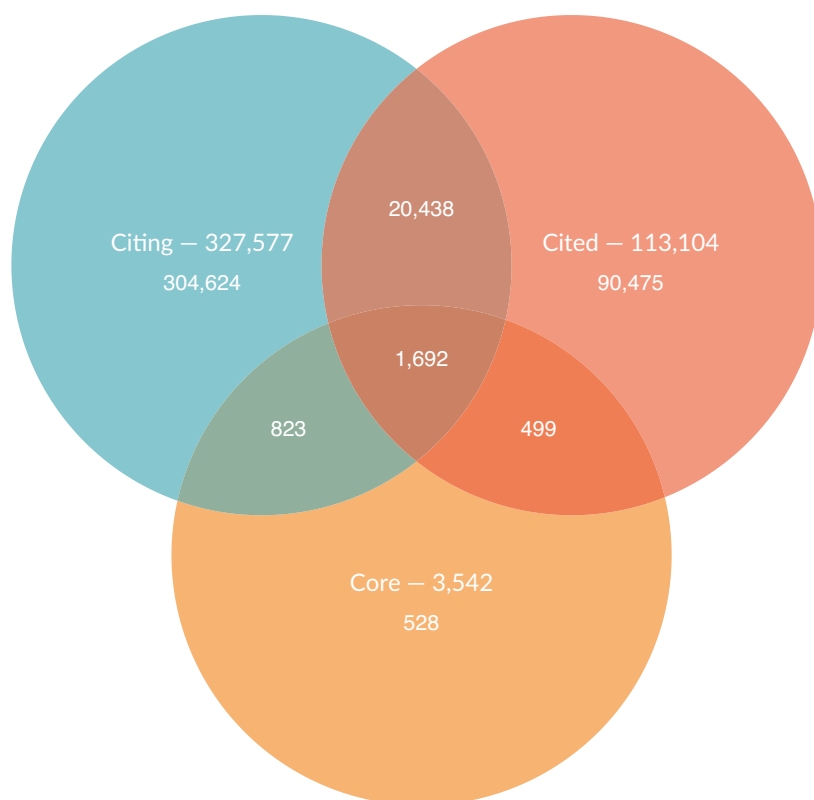
Figure 2. Venn diagram of the citation relationships between the documents from the core and full dataset based on references from the WOAII report.

core dataset also have a citing and cited-by relationship to other documents in the full dataset. The full dataset features 15,932 distinct sources (journals, book series, etc.). The most prevalent OpenAlex document type is the article ($n = 361{,}282$), followed by book chapters ($n = 25{,}129$), preprints ($n = 13{,}383$), reviews ($n = 6{,}948$), and dissertations ($n = 4{,}268$). The sources in the full dataset reflect a higher representation of specialized journals, such as *Science of the Total Environment* ($n = 7{,}888$), *Marine Pollution* ($n = 5{,}918$), *Frontiers in Marine Science* ($n = 5{,}602$), and *Marine Ecology Progress Series* ($n = 5{,}457$). Springer eBooks ($n = 6{,}426$) and Elsevier eBooks ($n = 4{,}856$) also occupy important positions, as do the preprint repository bioRxiv ($n = 4{,}751$) and the multidisciplinary journals *PLOS ONE* ($n = 4{,}659$) and Scientific Reports ($n = 3{,}656$).

4.3. The Identification of Ocean-Related Literature

Figure 3 highlights the findings of the process to identify ocean-related literature through the qualitative assessment performed on a random sample of 100 documents fitting each of the 24 possible combinations of the five criteria, for a total of 2,384 documents. The inclusion of several or all criteria (journals of publication, keywords, cited by, citing, and coauthorship) appears to have the most impact on helping the identification of research outputs, as all combinations that fit four or more of these criteria have a performance score above 90%. Keywords and journals are the factors that contributed the most to the identification of key research outputs, with performance higher for all combinations that included at least one of two compared to none, and combinations fitting both typically among the top in terms of performance score. Being cited by a core document also contributed slightly better than citing a core document in identifying relevant literature.
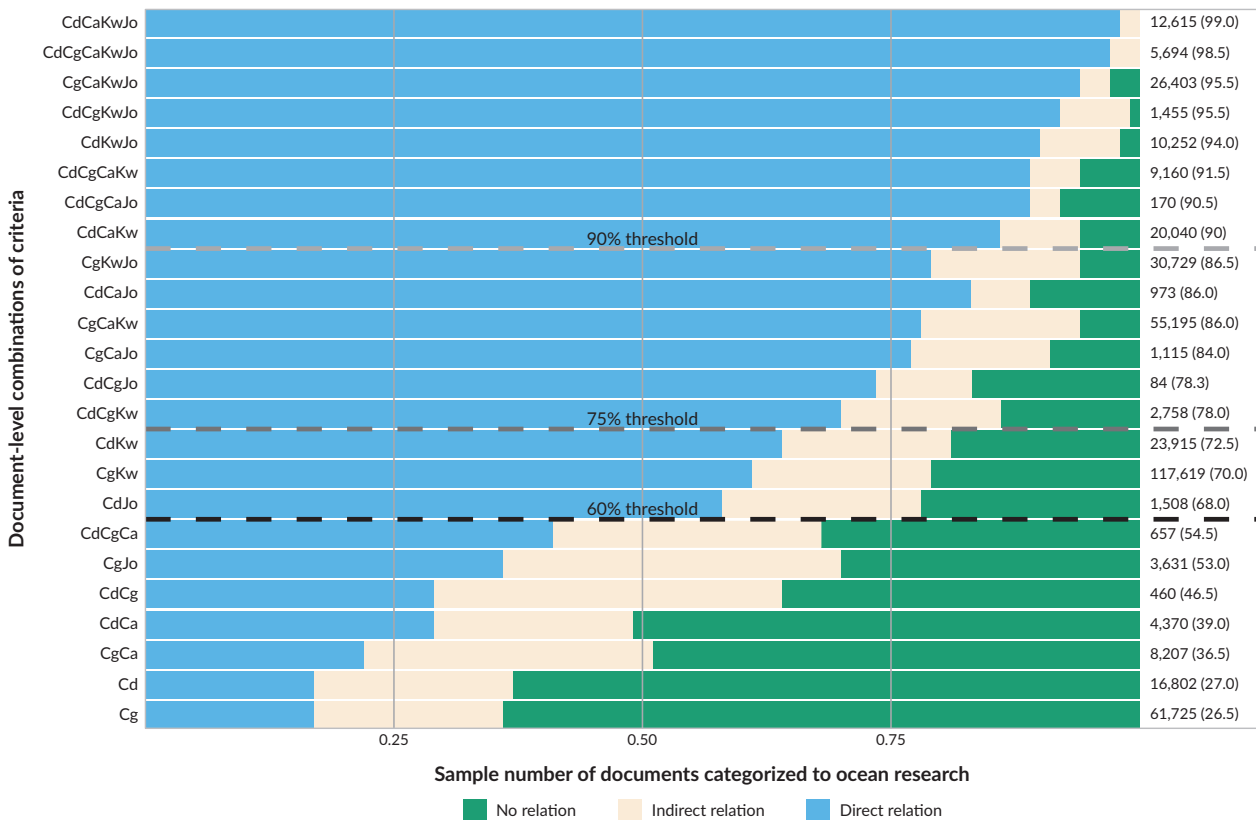
Figure 3. Results of the manual sampling of articles of all 24 possible combinations of criteria for ocean relation matching the documents in the full dataset. Notes: CdCaKwJo means that these papers were cited by the core dataset, had a Ca with papers from the core dataset, including at least one relevant keywords from the list established for this study, and were published in a journal related to oceans; each bar represents the % of papers (out of 100 for each category) that were coded based on the relation of the paper to oceans; the numbers on the right indicate the number of papers fitting a given combination as well as the performance score of the combination to capture relevant ocean research outputs.

We then compared three performance score thresholds at 60% (Figure 3, above the black line), 75% (Figure 3, above the dark grey line), and 90% respectively (Figure 3, above the light grey line). The threshold of 60% includes 319,685 documents from the full dataset excluding core documents, whereas the threshold of 75% includes 176,643 documents, and the 90% threshold includes 85,789 documents. However, the probability of them being ocean-related research papers diminishes significantly with lower thresholds. Looking at the prevalence of document types between the three thresholds datasets, we observe that articles ($n = 81,793$), book chapters ($n = 1,621$), and reviews ($n = 997$) are the most present in the 90% dataset, compared to articles ($n = 162,006$ and $281,101$), book chapters ($n = 5,804$ and $16,148$), and preprints ($n = 4,640$ and $9,784$) in the 75% and 60% datasets respectively. The identification of documents other than research articles appears to diminish drastically with a stricter threshold, likely due to the inclusion of the source or journal name as part of the identification process.

4.4. Assessing the Position of the Literature Cited in the WOAII Report

Comparing datasets, observations of the core dataset indicate that research outputs cited in the WOAII report stem more from open access and high-profile journals, such as *PLOS ONE*, *Scientific Reports*, *PNAS*, *Science*,

and *Nature*, whereas the top sources in the full dataset appear to be more topical, such as *Science of the Total Environment*, *Marine Pollution Bulletin*, *Marine Ecology Progress Series*, and *Geophysical Research Letters* (Figure 4). In both datasets, *Frontiers in Marine Science* occupies a central place among the cited sources, whereas *Marine Policy*, a topic journal in ocean social sciences, also ranked among the most cited journals of the core dataset. The International Union for the Conservation of Nature Red List of Threatened Species, an authoritative source produced by the International Union for the Conservation of Nature documenting the status of endangered species, also occupies a central role among the references used in the WOAII report. Looking at the sources included at various thresholds, we observe that the number of distinct publication sources diminishes from 10,992 at the 60% threshold to 4,361 at 75% and 2,398 at 90%. Across the three thresholds, the journals *Marine Pollution Bulletin* ($n = 3,540$, 90%; $n = 5,860$, 75%; and $n = 5,880$, 60%), *Frontiers in Marine Science* ($n = 3,585$, 90%; and $n = 5,574$, 75% and 60%), and *Marine Ecology Progress Series Bulletin* ($n = 4,339$, 90%; $n = 5,385$, 75%; and $n = 5,443$, 60%) are typically among the most prevalent sources, although *Science of the Total Environment* ($n = 7,045$) has the most references at the 60% threshold. As shown in Figure 4, the most
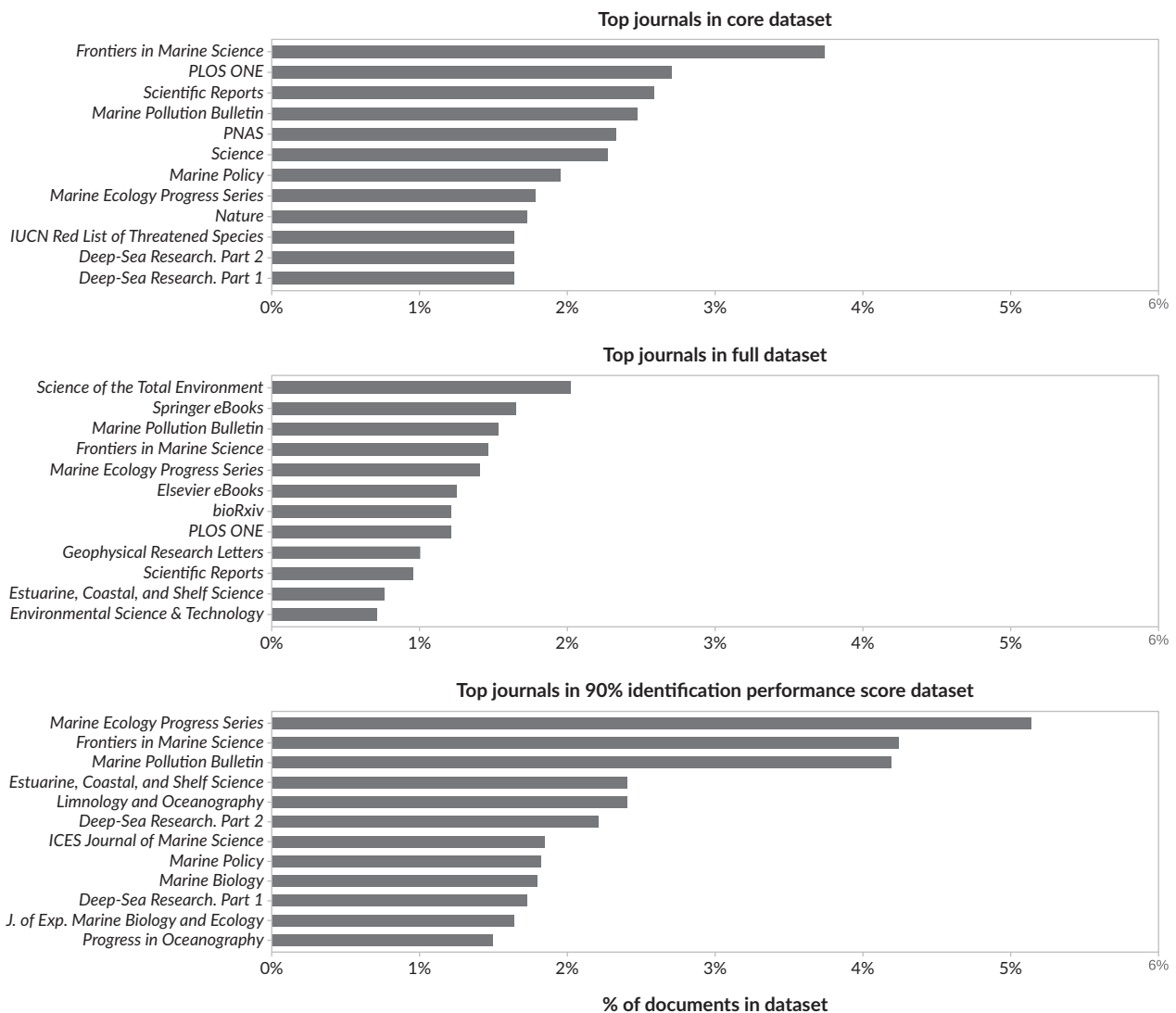
Figure 4. Sources with the most publications in the core dataset, full dataset, and full dataset after filtering the articles that matched the combinations with a performance score above 90%. Note: Sources are plotted based on the relative proportion (%) of articles in the dataset.

central sources included at a 90% performance threshold are more topically oriented toward ocean-related research, mostly due to the inclusion of topical keywords and journals in the identification process. A table with the segmentation of relevant references by chapter is available in Table 5 of the Supplementary File.

5. Discussion

The WOAII report acts as an authoritative document for ocean decision-making and a brokering channel synthesizing critical up-to-date knowledge about the state of oceans worldwide. As stated by Evans et al. (2021), the assessment aims to be a central point of convergence for the collective understanding of oceans, with the objectives of shaping ocean governance, ocean literacy, and ocean action. Therefore, the WOAII and similar seminal knowledge syntheses present a unique opportunity to investigate the construction of and engagement with scientific knowledge outside of academia, especially in processes informing decision-making. Our findings show that this second version of the assessment presents a partial synthesis of the research literature. Despite being the result of a careful and thorough collaborative information-gathering process, the selection of sources in each chapter is dependent upon the strategy and perspective of the group of experts. When it comes to the use of research-based knowledge, our findings show significant differences in the number of references to research outputs cited in each chapter of the report, as well as a reliance on other document types. As an example, Chapter 19 "Changes in Hydrocarbon Exploration and Extraction" cites more reports and grey literature than research articles, likely the result of the specific information practices related to this topic. Therefore, research outputs may be more or less mobilized to address certain topics, especially when other types of knowledge may act as the foundational blocks of expert communities, such as in the case of Chapter 19. These findings also corroborate a point raised by Evans et al. (2021) that future assessments should increase engagement with research and researchers, especially from social sciences disciplines. They also highlight potential gaps in the coverage of selected topics. Nevertheless, the research paper is the main type of document cited in the report, thus indicative of a strong reliance on traditional research outputs in the production of the report.

A second empirical finding of this study relates to the high reliance on papers published in high-profile, multidisciplinary sources when it comes to citing ocean-related research literature in the WOAII. Despite specialized journals, such as *Marine Pollution Bulletin* or *Marine Ecology Progress Series*, appearing as key sources in the full dataset of this study, articles published in *PLOS ONE*, *Scientific Reports*, *PNAS*, *Science*, and *Nature* occupy a central role among the top cited sources in the report, alongside other specialized sources like *Frontiers in Marine Science* and *Marine Policy*. These findings highlight the central role that high-profile journals, like *Nature* and *Science*, play at the science-policy interface; as authoritative sources both in and outside the scientific community, referencing material from these journals could foster credibility by relying on their reputations as high-impact research sources to demonstrate the current state of knowledge about oceans (Alperin et al., 2024). This elicits questions about the unique roles of both high-profile journals and more specialized sources in shaping the collective understanding of research knowledge on certain topics. Research published in high-profile, multidisciplinary journals may be authoritative for decision-making as these journals typically have high scientific publishing standards while benefitting from mechanisms favoring engagement outside of academia, such as historical public reputation or mechanisms that encourage open access publication and broader public outreach. Papers published in specialized journals can also generate significant public interest but may traditionally be less visible than those published in public-facing, high-profile sources. Future research could look at the topics published in either type of source and consider

how the articulation of research published in multidisciplinary and specialized journals may facilitate the mobilization of knowledge in decision-making processes.

The goal of this study is also to present methodological considerations about the use of knowledge synthesis reports for scholarly communication studies and bibliometric assessment about topical objects, such as oceans. As official documents produced by experts in their field, these documents present opportunities for a critical examination of the structure of research knowledge about said topics. Our objective was to link the literature cited in the WOAII report to other research outputs to build a dataset about ocean-related research, thus using the report as an anchor point to build a comprehensive understanding of ocean research. However, as not all research outputs citing or cited by the references included in the report necessarily dealt with oceans, we crafted a process to identify papers based on a combination of five criteria that could indicate a socio-topical relationship, that is a relationship that is informed both by the social and thematic ties between documents, with ocean research (Mongeon, 2018). Through this process, we observed that keywords and journals were the best indicators to identify relevant papers about oceans, with a combination of multiple criteria yielding even better results. Building on previous scholarly communication studies, the findings associated with the development of this process may facilitate the identification of research linked to other policy documents or socially relevant topics (Armitage et al., 2020; Kashnitsky et al., 2024; Purnell, 2022). They also inform future approaches by highlighting how a series of criteria—citing relationships, cited by relationships, co-authorship relationships, keywords, and journals—contribute to the identification of research outputs.

On top of these methodological considerations, our study highlights how a comprehensive dataset of ocean research would help achieve the goals of the UN Decade of Ocean Science for Sustainable Development (UNESCO, 2017) in facilitating the integration of scientific knowledge in processes informing ocean governance. This dataset and related tools could facilitate the access of relevant information for future assessments, as well as for targeted audiences involved in ocean literacy and ocean action (Evans et al., 2021). Such a database could eventually help identify coverage differences between topics, regions, and cultural settings, helping interested audiences find the relevant knowledge outputs they need. Using this approach, further questions could be asked, such as whether factors exist that make some research outputs less likely to be mobilized, how the WOAII might impact science communication, and what is the nature of the information practices of those who contributed to the report. The development of this kind of dataset would nevertheless require significant consideration for data quality and access to scholarly databases to maintain a continuous and exhaustive input of new research (Riddle et al., 2024).

5.1. Limitations and Future Research

While multiple types of outputs are cited in the WOAII report, this research focused specifically on research outputs as indexed in OpenAlex, an open bibliographic database for scholarly communication. Despite covering a broad body of research, the full dataset of papers we collected is not an exhaustive representation of ocean research but rather reproduces a partial and selective view of ocean literature on a larger scale, built upon the knowledge that served as foundations of the WOAII report. Further citation analyses incorporating natural language processing techniques to analyze the text contained in the report could improve this representation by discovering linkages and text similarities between papers. This representation of ocean research literature is also partial in that it builds on the information made available by scholarly information platforms, in this case, OpenAlex. Different platforms, such as Web of Science,

Scopus, or Google Scholar provide a distinct coverage of research outputs and related metadata (Culbert et al., 2024). The advantages of using OpenAlex reside in it being an open platform designed by scholars, thus more accessible and in line with research needs, rather than a proprietary platform. Data quality nevertheless remains an important issue for bibliometrics analysis, as metadata entry is usually performed at the publishing level, with different standards between publishing platforms (Schares, 2024). In that regard, OpenAlex offers a wide coverage of research outputs while also benefiting from the continuous output of a team of scholars to maintain data quality standards. However, certain pieces of information, such as publication year or number of citations, are dependent on the data entry process performed through the publishing process and, therefore, should be subject to caution and careful data processing (Besançon et al., 2024; Delgado-Quirós & Ortega, 2024). While performing better than other indexing platforms, such as the Web of Science or Scopus, research not published in English or region-specific research outputs may also lack coverage in OpenAlex (Céspedes et al., 2024). Therefore, this study provides a partial view of ocean-related research outputs as indexed in OpenAlex and collected through the use of DOIs and Crossref data, thus focusing on a specific set of research publications compared to other types of documents.

Future research will aim to improve the current methodological framework presented in this study by integrating clustering and natural language processing techniques into citation analysis, thereby producing maps of the structure of knowledge in ocean research (Colavizza et al., 2021). It will also focus on expanding and improving the dataset presented in this study toward an exhaustive representation of the field of ocean-related research. Among empirical studies to be conducted, future detailed assessments of document types by chapters would also help critically examine information practices related to specific topics. For example, future studies could assess the role reviews play in producing a state of knowledge about oceans, as well as the prevalence of grey literature to inform certain topics. Through the clustering of research outputs, we also aim to identify socio-topical structures that could provide information on the topics and groups involved in ocean research, as well as examine eventual attention gaps through citations and mentions outside of academia (Toupin et al., 2023). This will create an opportunity to look at the knowledge trends and discrepancies in research literature about oceans, for example by examining whether certain topics are more or less discussed through various mediums. On top of these future research paths, the process developed in this study could also be applied to other policy documents, for example, to identify ocean research outputs that are mobilized to inform policymaking. Finally, we aim to leverage interactive visualization tools to facilitate the discovery of relevant literature about oceans.

6. Conclusion

This research looked at the integration of research outputs in the UN WOAII report. Through the analysis of citations to and from the research outputs included at the end of each chapter of the report, we examined the references used across chapters, specifically the distinct reliance on research outputs in the preparation of the chapters about specific topics. We also observed that the outputs cited in the report occupy a distinct position compared to a broader ecosystem of ocean research, relying mostly on research published in high-impact journals compared to more specialized sources that frame the field of ocean science. This finding corroborates the role that high-profile sources may play at the science-policy interface. As historically authoritative sources, journals like *Nature* or *Science* may provide critical public credibility to the research they publish. We also took the WOAII report as an opportunity to look at a proof-of-concept and a methodological framework to use these knowledge syntheses as a basis to identify a broader set

of research outputs about a specific topic, specifically oceans in this case, as well as to examine the engagement with research related to oceans.

Existing research applies useful methodological tactics for capturing and analyzing research on specific topics, yet much of the literature is missed, and existing structures are subsequently reinforced rather than transgressed. Further research on the science of science is needed to critically examine how the production and selection of research may inhibit its own transformation (Turnhout, 2024). This article presented a methodological approach that leverages the expertise, purposeful selections, and dynamic, collaborative processes that produced the WOAII to capture a broader range of knowledge than query-based or automated processes used in isolation could produce.

The integration of research outputs in ocean policymaking and management is key to achieving the targets of the UN Decade for Ocean Science and to better inform ocean governance. The findings reported in this study could help authors of future WOAs identify relevant literature and improve the coverage of existing knowledge on topical issues related to oceans in an interdisciplinary fashion, a key issue raised by Evans et al. (2021). A broad and exhaustive picture of ocean research could facilitate the communication of relevant knowledge to decision-makers and other audiences, thereby improving our understanding of oceans and fostering ocean action.

Conflict of Interests

The authors declare no conflict of interests.

Data Availability

All scripts created for this study are available at: https://github.com/toupinr/ocean_research. The data related to the project can be found at: https://doi.org/10.5281/zenodo.14082108

Supplementary Material

Supplementary material for this article is available online in the format provided by the author (unedited).

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ARTICLE

From Individual Observations to Global Assessments: Tracing the Marine Carbon Knowledge Value Chain

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Abstract

Marine carbon observations (MCOs) provide essential data to trace historical and current changes in marine carbon storage and fluxes that ultimately feed into the Global Carbon Budget and the Intergovernmental Panel on Climate Change report. Therefore, MCOs play a key role in informing global climate policy as well as ocean governance. However, they only achieve this potential if multiple sources of observations are combined and analyzed jointly. This implies an immense coordination effort by the international MCO community which developed, e.g., joint standards for the collection of (meta-)data, quality control processes, data platforms, etc. This article traces the value chain of MCOs, concretely for CO_2, from data collection to the Intergovernmental Panel on Climate Change report. Based on an interdisciplinary research project, the study illuminates which structures and practices the marine carbon community has developed to integrate different observations and measurement technologies, starting from German research institutes and agencies and expanding to the European and international networks to which they contribute. Combining a social network analysis with qualitative insights from in-depth interviews, the article identifies key information providers and brokers and pinpoints systemic vulnerabilities, e.g., where connections between observation networks or data platforms are maintained based on personal relationships or ad-hoc interactions rather than automated data submissions, or where temporally limited third party funding threatens the continued existence of the observation network.

The article concludes with recommendations on how the MCO network can be maintained and improved as an exemplary achievement of bottom-up coordination in scientific knowledge production.

1. Introduction

The ocean absorbs roughly one-fourth of annual global CO_2 emissions (Friedlingstein et al., 2023; Global Carbon Project, 2023). Next to the atmosphere, which takes up 47%, forests, grass, and wetlands, which together make up 36%, fulfill an essential function in regulating the global climate and in buffering the human perturbation of the global carbon cycle. However, the latest iteration of the Global Carbon Budget (GCB; Friedlingstein et al., 2023) has shown that the effects of climate change are compromising both the ocean's and the land sinks' capacity to take up greenhouse gases. Increasingly, the ocean has also become a focus of carbon dioxide removal strategies, which include plans for the enhanced capture and storage of carbon dioxide, e.g., under the seabed (e.g., Mengis et al., 2023).

Understanding the dynamics of the marine carbon cycle and how climate and other changes affect it, as well as observing the exchange of CO_2 between the atmosphere and the ocean (marine CO_2 fluxes), is therefore essential for informed climate policy at the national and international scale. However, these insights stand at the end of a value chain that starts with an extensive number of individual measurements of marine CO_2. Ensuring that these measurements can be combined and analyzed jointly, as well as aggregating and synthesizing them, requires a massive coordination effort on the part of the international scientific community.

Over the last 15–20 years, this community has organized itself in a bottom-up process (e.g., Steinhoff et al., 2019; Wanninkhof et al., 2019). Through dedicated scientific conferences, research networks, and data platforms, scientists have created a global knowledge production and transfer system that permits the continuous measurement of key parameters to characterize and analyze the oceanic inorganic carbon system, to which marine CO_2 belongs. However, this bottom-up organization is reaching its limits. Over the last few years, the global capacity to observe surface ocean carbon to determine CO_2 fluxes has diminished rather than increased (Bakker et al., 2024)—precisely at a time when this knowledge is needed more than ever to design policies and evaluate measures to tackle climate change.

This article investigates the knowledge network that has created and maintained the value chain of marine carbon observations (MCOs) from data collection to the Intergovernmental Panel on Climate Change (IPCC) report, illuminating how and where different observations and measurement technologies are integrated. It conducts a social network analysis (SNA; e.g., Borgatti et al., 2013; Hanneman & Riddle, 2005) to identify key information providers and brokers (i.e., actors that connect disparate parts of the network; Meyer, 2010) and complements this analysis with information from in-depth interviews and participant observation to understand where vulnerabilities in the knowledge system exist and how they could be addressed. In that manner, the article contributes to debates among researchers from the MCO community as well as to the

social science fields interested in opening the black box of academic knowledge production (Latour, 1987). It is the result of and reflects the findings of a three-year-long, interdisciplinary research project comprising social scientists, oceanographers, and biogeochemists.

Our investigation starts from the German MCO network. From there, it extends to the inter and transnational networks in which researchers from German organizations are embedded and to which they contribute. While the German MCO network shares some characteristics with those of other European countries (e.g., a somewhat decentralized organization of research, and a split between atmospheric and oceanic measurements), national networks can also be organized differently, taking, for example, a centralized approach that integrates atmospheric and marine observations, like the USA's National Oceanic and Atmospheric Administration does.

The article starts with a brief introduction to the marine carbon cycle and the observation networks that have been built to understand and monitor it, providing some insights into its historical emergence and development. We then introduce our data collection and SNA in Section 3 before presenting our results in Section 4, drawing on SNA findings and interview data to interpret network characteristics. In Section 5, we dive more deeply into the dynamics of the scientific system, discussing strengths and vulnerabilities. We conclude with a summary of our findings and a set of policy recommendations in Section 6.

2. The Marine Carbon Cycle and the Observation Network

2.1. The Marine Carbon Cycle

Out of all the natural carbon sinks, the ocean contains the largest carbon pool, of which the majority is inorganic carbon (Figure 1; Friedlingstein et al., 2023; Global Carbon Project, 2023). The inorganic carbon pool is represented by the variable dissolved inorganic carbon (DIC), which summarizes the concentrations of all DIC species (CO_2, bicarbonate HCO_3^-, and carbonate CO_3^{2-}) in seawater. Via air-sea gas exchange, CO_2 is constantly transferred between the atmosphere and the ocean. With rising CO_2 levels in the atmosphere, CO_2 uptake at the ocean surface has also increased, resulting in higher levels of oceanic DIC. Anthropogenic CO_2 uptake in the ocean can thus be quantified by comparing DIC measurements over time.

For air-sea exchange processes, the partial pressure of CO_2 (pCO_2) at the sea surface is particularly important. Together with wind speed, the difference between atmospheric pCO_2 and sea surface pCO_2 determines the direction and magnitude of the air–sea CO_2 flux, i.e., whether and how much CO_2 the ocean takes up from the atmosphere or vice versa, which varies seasonally and spatially (Takahashi et al., 2009). The oceanic inorganic carbon system has four measurable parameters: pH, DIC, total alkalinity, and pCO_2. It is sufficient to measure two of any of these four parameters to be able to calculate all other parameters of the inorganic carbon system based on knowledge of the environmental and equilibrium conditions (S. Emerson & Hedges, 2008).

2.2. Current State of MCOs and Historical Embedding

MCOs have traditionally been based on water samples taken from a research vessel and analyzed in the laboratory, relying on high-accuracy laboratory methods tailored to the measurement of marine inorganic carbon parameters (Dickson et al., 2007). These protocols were coordinated globally for the first time in the
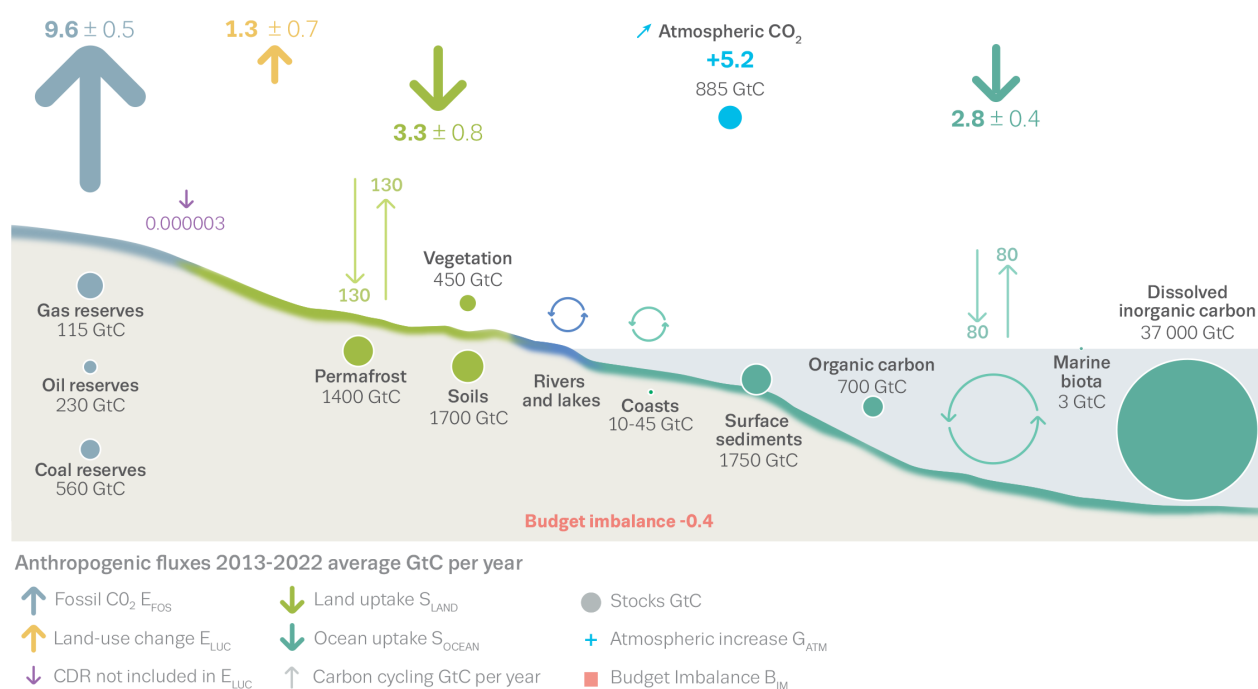
Figure 1. The global carbon cycle, including a quantification of different carbon sinks and anthropogenic fluxes from 2013–2022. Note: CDR is an acronym for Carbon Dioxide Removal. Source: Global Carbon Project (2023).

so-called GO-SHIP program, which emerged from the World Ocean Circulation Experiment in 1988–1998. The World Ocean Circulation Experiment collected research-vessel-based surveys of DIC on 40 basin-crossing transects, which, for the first time, allowed the tracing of anthropogenic CO_2 uptake and redistribution in the water column.

In the 1990s, improved and more automated instrumentation measuring surface ocean carbon to investigate CO_2 fluxes was established. This instrumentation permitted direct, high-accuracy measurements of pCO$_2$ from a seawater intake while the ship is underway thanks to additional reference gasses, and ancillary parameters like sea surface temperature and salinity (Pierrot et al., 2009). By installing such systems on commercial vessels, so-called Ships of Opportunity (SOOPs) were established, allowing commercial vessels to take continuous measurements along their regular routes and alleviating the need for a dedicated scientific ship and crew. This increased geographical and temporal coverage significantly. Given the increasing amount of pCO$_2$ data measured by different sources, participants at the UNESCO workshop Surface Ocean CO_2 Variability and Vulnerability agreed in 2007 that an effort was needed to make these data available on one single platform and in one common format. From this, the Surface Ocean CO_2 Atlas (SOCAT) emerged as a voluntary activity maintained by the global marine carbon community.

The early 2000s also saw an effort at the European level to establish a research infrastructure to integrate and coordinate carbon observations. Initially, these efforts focused on atmospheric and terrestrial observations but once the Integrated Carbon Observation System (ICOS) reached the preparatory stage, it expanded its scope to include MCOs as well. Today's ICOS marine observations rely on SOOP-based, underway observations as well as those on oceanic time series stations, which use submersible inorganic carbon sensors attached to moorings (Schuster et al., 2009) to continuously measure surface pCO$_2$ at a fixed location.

Such sensors are the most recent development in MCO methods, and techniques are continuously developed to improve their accuracy and stability. The development of small pH sensors allows the augmentation of SOOP-based observations with additional marine inorganic carbon system variables, as well as the expansion of carbon measurements to platforms such as the profiling Argo floats, which are autonomous, free-drifting platforms. Originating as a global program with over 30 member states in the 2000s, Argo floats revolutionized real-time data availability, providing synoptic global coverage of in-situ observations for the first time. While the original Argo program focused on temperature and salinity observations, the development of new sensors has allowed the program to include biogeochemical parameters as well (Roemmich et al., 2019), leading to the establishment of the biogeochemical Argo sub-program (BGC-Argo). Depending on the sensors attached, BGC-Argo floats either measure pCO_2 directly or parameters such as pH and dissolved oxygen, which can be used to calculate pCO_2. This can be done, for example, by drawing on pH values measured by the floats and estimates for total alkalinity based on regional relationships with salinity. Internationally, other efforts surrounding surface buoy data, coastal flux measurements, and non-surface observations beyond the Argo program also aim to refine and expand MCOs.

3. Concept and Methodology

Conducting science is an inherently social process (Latour, 1987) in which humans seek to understand their environment through the systematic collection and interpretation of information. Beyond the social practices of making meaning out of collected data shaped by specific sets of beliefs (Berger & Luckmann, 1966), science itself is also a social system with its operational logic and rules (e.g., regarding quality assurance, notions of good performance, etc.), communicative codes, forms of self-referencing, boundary creation, and auto-generation (Luhmann, 1984). As a social system, science and its respective sub-systems have a particular structural organization and functional differentiation, e.g., regarding funding streams, data collection, analysis, and provision, and the generation and dissemination of products. Therefore, understanding how scientific knowledge on marine CO_2 is produced—through the joint analysis of numerous instances of observation and various steps of aggregation and abstraction—and identifying potential path dependencies and vulnerabilities requires an analysis of the structural properties of this particular sub-system. This includes an analysis of the networks of actors that constitute it (Latour, 1987).

SNA is a useful method to do so, as it investigates social systems by looking at the relationships between different actors (see Borgatti et al., 2013; Hanneman & Riddle, 2005). It has been applied to various fields within the social sciences, including scientific collaborations and information exchange (e.g., Hatala & Lutta, 2009; Kardes et al., 2014; Long et al., 2015). It seeks to understand how actors ("nodes"), are connected and how an actor's characteristics ("attributes") influence their connections ("ties") or their position in the network, and vice versa. Ties can represent any type of relationship and they can be directed (e.g., when someone sends funds to someone else) or undirected, when two scientists collaborate on a publication, for example. Essential queries pertain to the network as a whole, e.g., to its so-called density, measuring how well actors are sharing information overall, or to the roles of specific actors. These can include gatekeeping or brokerage, i.e., when one actor connects two otherwise separate parts of the network ("betweenness" in SNA). In that position, the actor can either prevent the flow of information—serving as a gatekeeper—or support it and effectively link both parts of the network—serving as a knowledge broker (e.g., Behrend & Erwee, 2009; Cvitanovic et al., 2017). Other essential information gained from SNA pertains to the roles of sender vs. receiver in directed networks, measured by the number of outgoing or incoming ties, respectively.

As the MCO value chain requires extensive coordination among different actors and the exchange of various kinds of information, an SNA approach is useful to identify key players and potential bottlenecks. Combined with the information from in-depth interviews, this allows us to understand where the knowledge system is vulnerable and how the community has attempted to address these vulnerabilities.

In this article, SNA is used to assess how information flows between different actors engaged in MCOs and the associated science-policy interface. Nodes in the network represent organizations distinguished by kind (e.g., governmental agencies, research institutes, data platforms, etc.) and scale (e.g., rooted at the German national level, the European level, or the international level). Ties are directed and represent the sending or sharing of information (see data matrices in Supplementary Files). We conducted two separate analyses, one for the MCO knowledge network as a whole, and one for the sub-sample of the network that includes surface observations only. The former gives insight into the whole of MCO knowledge generation, while the latter illustrates whether there are specific characteristics for this smaller network, on which the MCO value chain has long relied, that might differ from the more extended picture.

Data for this article were collected between 2020 and 2023, in semi-structured interviews ($n = 26$) with scientists from Germany, Brazil, the UK, and Australia who contributed to different steps along the knowledge creation value chain (Mason, 2002). Interview questions included queries about (a) from whom actors received information related to MCO (data processing, interpolation, etc.) and (b) to whom they provided this kind of information. Data collection followed a purposive sampling process, deliberately selecting actors along the value chain, and included elements of snowball sampling, when interviewees pointed out other actors in the network (Jupp, 2006). Interviewees covered the entirety of the German MCO network and an illustrative sample of the international network into which this is embedded, covering essential actors along the value chain (e.g., ICOS and GCB). However, it did not manage to include actors engaged in the interpolation step of the value chain, which is therefore missing from the SNA. Next to SNA-specific questions, interviews primarily consisted of open-ended questions pursuing information on the tasks of different actors, and their perception and evaluation of the state of MCOs. Data collected also included various instances ($n = 8$) of participant observation during virtual and in-person meetings of organizations such as Argo, Argo Germany, ICOS, and ICOS Germany that were recorded in field notes (R. M. Emerson et al., 2001).

Interviews were transcribed and analyzed through a qualitative interpretative analysis (Heron, 1996), applying a bottom-up coding strategy and using the software Atlas.ti. For the SNA, qualitative information was translated into a two-dimensional matrix describing the flow of information between actors (see Supplementary Files). Weights from 1 to 4 were first assigned by the first author based on information reported in the interviews, evaluated by the co-authors, and then amended, in order to describe the intensity of information flow. 1 represents personal, ad-hoc information sharing, 2 represents institutionalized information sharing, 3 represents close ties and frequent exchanges, and 4 represents embodied links, i.e., when a person of one organization also works for another and thus unifies knowledge from both entities. The SNA was conducted with R Studio. Information on the specific software packages, queries, and their results are reported in the Supplementary Files.

4. MCOs as a Transnational Network

4.1. The Marine Carbon Value Chain and Its Contributors

Knowledge generation about the ocean as a dynamic carbon reservoir and sink starts with in-situ MCOs taken by fixed observation stations, research vessels, or SOOP lines. These data then undergo quality control to ensure that they are not subject to instrument failure or detectable measurement errors before they are submitted to SOCAT, where they are fed into the database and made available in two synthesis products: a global dataset of surface ocean $p\text{CO}_2$ and a gridded product of monthly surface water $p\text{CO}_2$ means.

Yet, combining data from different sources requires additional coordination as they need to be submitted in the same format and undergo the same quality control process to make them comparable, and to make claims regarding the accuracy of the final product. Scientists involved in SOCAT have created a protocol for sampling, quality control, and the submission process itself, which they update when the need arises, e.g., due to technological innovation, new scientific insights, or changes to the platform (Lauvset et al., 2018). This protocol includes the assignment of quality flags to communicate uncertainties transparently and a two-step quality control process where data are first controlled by the researcher submitting them but then also by another researcher from the community. The protocol and products are available via the SOCAT website, where contributions such as data submission or peer quality control are also recognized. Any researcher can contribute data to SOCAT as long as they fulfill the requirements laid out in these documents.

At the European level, in-situ surface MCOs are coordinated by ICOS, specifically the Ocean Thematic Center (ICOS-OTC). ICOS-OTC keeps an overview of carbon observations at the sea surface. It provides technical support to the individual measurement stations that are part of ICOS and coordinates the setting and implementation of joint standards for data collection that are developed in a bottom-up process, drawing on the experiences and expertise of the stations' principal investigators. Similarly, ICOS-OTC has coordinated the establishment of a protocol for subsequent quality control and provides an infrastructure for data management that is aligned with the SOCAT procedures to ensure usability and interoperability. Horizontal integration, i.e., coordination with terrestrial and atmospheric carbon observations, which also have dedicated thematic centers similar to the OTC, is provided by the national chapters of the member countries in the program, through an integrated data portal, and by the head office of ICOS. It is also at these levels that efforts are made to communicate the importance of these observations and to lobby for political attention and support, with national nodes doing so at the country level and representatives of the head office pursuing lobbying and communication efforts at the international scale, e.g., by participating at the Conference of the Parties (COP). ICOS as an entity is financed by the states that are members of it but the research infrastructure for MCOs themselves and the personnel conducting them is usually financed by individual agencies, research grants, etc.

To achieve the current quality and consistency of MCOs, the community has developed and provided seawater reference material for marine inorganic carbon analysis (Dickson et al., 2003), which assures that measurements are consistent across laboratories. It has also conducted intercomparison exercises to assess the level of accuracy achieved by various marine laboratories and systems and continues conducting them, for example, different instruments (Bockmon & Dickson, 2015; Körtzinger et al., 2000).

SOCAT gridded product is a synthesis product but one that does not interpolate, meaning that geographical and temporal gaps in the dataset remain as such. At the moment, these gaps are predominantly located in the Southern Ocean, South Pacific, South Atlantic, and Indian Ocean, where less commercial shipping activity and fewer research missions take place. Interpolated products use a variety of statistical and computational techniques to estimate values in unsampled areas, combining, e.g., machine learning and/or satellite data with SOCAT's observational data to create a product with continuous spatial fields that covers the ocean in its entirety (Gregg et al., 2003; Landschützer, 2016, 2020a, 2020b; Rödenbeck et al., 2013; Troupin et al., 2012). Interpolated maps are vital for climate models, which require complete data sets for boundary conditions and validation. They also allow researchers to calculate the carbon uptake of the ocean and quantify its function as a carbon sink. Doing so, and relating this value to other carbon sinks as well as anthropogenic CO_2 emissions is the task of the GCB. By estimating emissions from fossil fuel combustion and land use change, and balancing it against CO_2 uptake in the atmosphere, ocean, and on land, the GCB tracks how much carbon is entering the atmosphere due to human activity (Friedlingstein et al., 2023; Le Quéré et al., 2009). To do so, it draws directly on interpolated maps but also on SOCAT data, to assess the quality of model outputs. Its results are shared annually at the COP and data submission and quality control cycles of SOCAT are aligned with this schedule to ensure that updated data are available in time. The IPCC report, as the second final link in the value chain, refers directly to the GCB. Figure 2 shows the value chain and its respective components.

Various UN bodies report on oceanic observations related to CO_2 or try to coordinate them. The International Ocean Carbon Coordination Project provides coordination for the MCO community at the global scale, and serves as a bridge from the scientific community to policy-makers, a role that increasingly involves drawing attention to the importance of MCOs. The Global Ocean Observing System, which belongs to the UNESCO-IOC, seeks to coordinate ocean observations in general. To that end, it has established a list of essential ocean variables to be monitored globally, which includes all four variables of the marine inorganic carbon system. However, the IOC has no mandate to oblige member states to monitor these variables, thus drawing on its norm-setting power only. The Global Climate Observing System under the auspices of the World Meteorological Organization (WMO) coordinates observations of variables related to the global climate system and reports on marine carbon data as well.
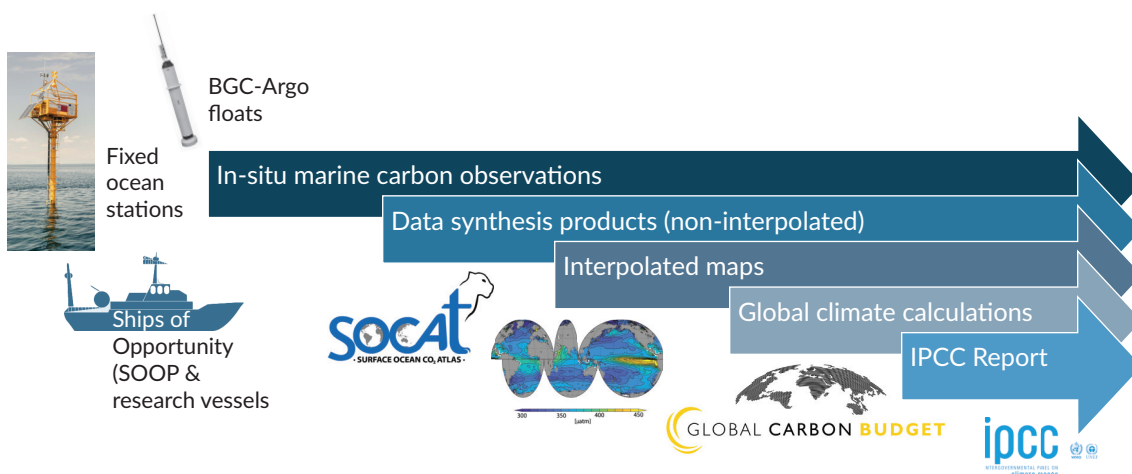
Figure 2. The value chain for MCOs.

To improve the understanding of the marine carbon cycle beyond the exchange of CO_2 at the ocean surface, to increase geographical coverage, and to extend measurements into the ocean interior, scientists have started to combine surface observations and observations of marine CO_2 across the ocean column collected by BGC-Argo floats, on top of other ongoing efforts mentioned in Section 2. However, integrating the measurements from floats is challenging as floats use different sensors from those generally used for surface observations. They are still comparatively new and target a different variable of the marine carbon system (pH vs. pCO$_2$). In addition, float sensors experience drift and need to be recalibrated against known standards. This can create issues regarding data accuracy and precision (Wimart-Rousseau et al., 2024). Integrating float data thus requires significant additional work, e.g., on the evaluation and improvement of pH sensor performance, the establishment of a new protocol that specifies requirements regarding accuracy, and the harmonization of data formats and metadata curation. At the moment, BGC sensors do not yet deliver data with sufficient accuracy to meet the requirements of SOCAT. Instead, they are submitted to the Global Argo Data Centers (Global DACs).

4.2. Analyzing the Flow of Information Across the Network

Various actors at the German, European, and international levels are involved in the MCO knowledge network. They provide, coordinate, or translate into policy advice scientific knowledge on marine CO_2 and thus fulfill different tasks at various points in the value chain. Table 1 provides an overview of those actors that were included in the SNA as part of the German MCO network and the European and international networks into which they are embedded. As data from BGC-Argo is not yet integrated into the MCO value chain, we ran two separate analyses, one focusing on the MCO knowledge network in its entirety (thus including BGC-Argo-related nodes and ties) and one with a sub-sample of the network focusing on surface observations only. Actors who are excluded from this second analysis are highlighted in blue. In addition to attributes like the scale and kind of the organization or program, Table 1 also indicates their core tasks concerning the MCO value chain, leaving aside the other work areas and related responsibilities. Some organizations are split into various entities located at different scales or with a slightly different focus. In these cases, we included the one most directly related to MCOs in the SNA and excluded the others, as indicated by the cells highlighted in grey. Due to limitations during data collection, actors related to the interpolation step in the value chain are missing from the analysis.

Table 1. Overview of German, European, and international actors involved in the MCO value chain and included as nodes in SNA.

| Name	Kind	Scale	Core task in relation to marine CO_2
Alfred Wegener Institute (AWI), Helmholtz center for polar and marine research	Research institute	National	Conduct observations (focus on polar regions) and contribute to modeling for the GCB
BGC-Argo	Research program	International	Coordinate observations via Argo floats with BGC sensors and establish protocols
Argo-D		National	Coordinate the German contribution to Argo, e.g., float deployment and science communication
Euro-Argo		European	Coordinate the European contribution to Argo

Table 1. (Cont.) Overview of German, European, and international actors involved in the MCO value chain and included as nodes in SNA.

Name	Kind	Scale	Core task in relation to marine CO_2
Argo International		International	Coordinate the Argo program overall
Federal Ministry for Education and Research (BMBF)	Ministry	National	Fund research
Federal Ministry for Digit and Transport (BMDV)	Ministry	National	Fund infrastructure for, e.g., weather observations
Federal Maritime and Hydrographic Agency (BSH)	Agency	National	Coordinate German contribution to Argo and conduct observation with Argo floats
COP to UNFCCC	Part of the UN system	International	Climate policy-making
GCB	Research program	International	Calculate the GCB, including ocean sink
Global Climate Observing System (GCOS)	UN body	International	Coordinate global climate observations
GEOMAR Helmholtz Center for Ocean Research Kiel	Research institute	National	Conduct observations via research cruises, SOOP line in North Atlantic, and fixed ocean station in Cabo Verde
Global DAC	Data platform	International	Provide quality controlled data in a unified format
Global Ocean Observing System (GOOS)	UN body	International	Coordinate ocean research generally
Helmholtz Center Hereon	Research institute	National	Conduct observations via fixed ocean station at the German North Sea coast
ICOS-OTC	Research program	European	Coordinate observations from various sources at the European level
ICOS-Head Office	Research program	European	Coordinate carbon observations (including terrestrial and atmospheric) at the European level
ICOS Germany	Research program	National	Coordinate carbon observations (including terrestrial and atmospheric) at the national level
International Ocean Carbon Coordination Project (IOCCP)	Part of the UN system	International	Lobby for the importance of research on marine carbon
UNESCO-IOC	Part of the UN system	International	Science-policy interface for ocean research
Leibniz Institute for Baltic Sea Research Warnemünde	Research institute	National	Conduct observations with BGC Argo floats and SOOP line in the Baltic Sea
IPCC	Part of the UN system	International	Synthesize climate research
SOCAT	Data platform	International	Provide quality-controlled data in a unified format
WMO	Part of the UN system	International	Coordinate research on the global climate system

Note: Entities highlighted in grey are part of the same overarching organization.

In both the full transnational network through which knowledge on marine CO_2 is produced and its sub-sample for surface-only MCOs, more than 60% of the ties are reciprocated, which demonstrates that entities that send information to others also receive information in return. Knowledge generation on marine CO_2 is thus not a unidirectional process. Rather, it requires an exchange between those who compile or aggregate data from different sources and those who collect it in the first place, e.g., to set standards together and to ensure that they remain up to date, or to coordinate observations in order to maximize geographical coverage. Indeed, in-degree centrality (Borgatti et al., 2013), which measures how many incoming ties an entity has, and out-degree centrality, which measures out-going ties, are significantly correlated ($r = 0.787$, $p = 6.335e\text{-}05$). The correlation becomes even stronger when looking at the network related to surface observations only ($r = 0.825$, p-value = 0.0001526), indicating that information providers are nearly always also information recipients and vice versa.

Interestingly, actors that are higher up the value chain (such as the GCB or the IPCC) have fewer incoming ties than those further down (see Figure 3), which means that the integration of knowledge—in this case, of data points, and common measurement and submission standards, etc.—occurs beforehand. This is independent of whether we assess the entire network or its surface-only part. They also have fewer ties
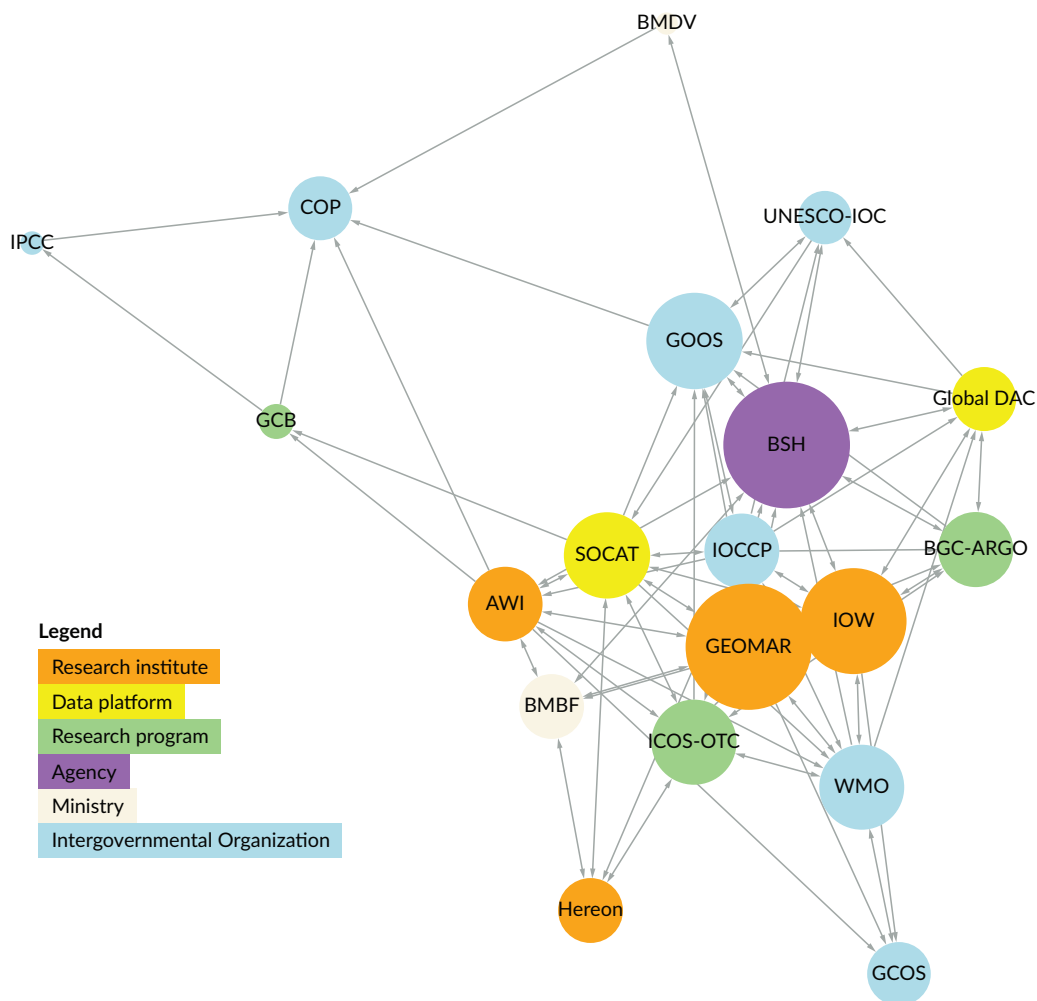
Figure 3. Full marine CO_2 knowledge network. Notes: Size of nodes according to the number of incoming ties; size of arrows according to the intensity of information sharing.

overall. This links to the comparatively low-density values of 0.35 and 0.32 that we find for the entire network and its surface-only sub-sample (Borgatti et al., 2013). In both, less than half of all connections that could, theoretically, be established between different actors are actually established and used to share information. Considering the notion of the value chain and the information supplied in the interviews, these measures reflect the successful division of labor: As knowledge is aggregated and shifted up along the value chain, there is less need for actors such as the GCB or the IPCC to draw information directly from actors engaged in MCOs. It also reflects the linear nature of the value chain where the IPCC and the COP are considered the endpoints, whose audience lies outside of the network assessed here.

As Figure 4 shows, the betweenness values in the full MCO network, which show the extent to which an entity connects disparate parts of the network (Borgatti et al., 2013), are comparatively high for research institutes such as GEOMAR and AWI and for the German maritime agency BSH (exact values are reported in the Supplementary Files). These actors thus have the capacity to act as knowledge brokers and, based on information provided in the interviews, effectively seek out information exchange across the network.
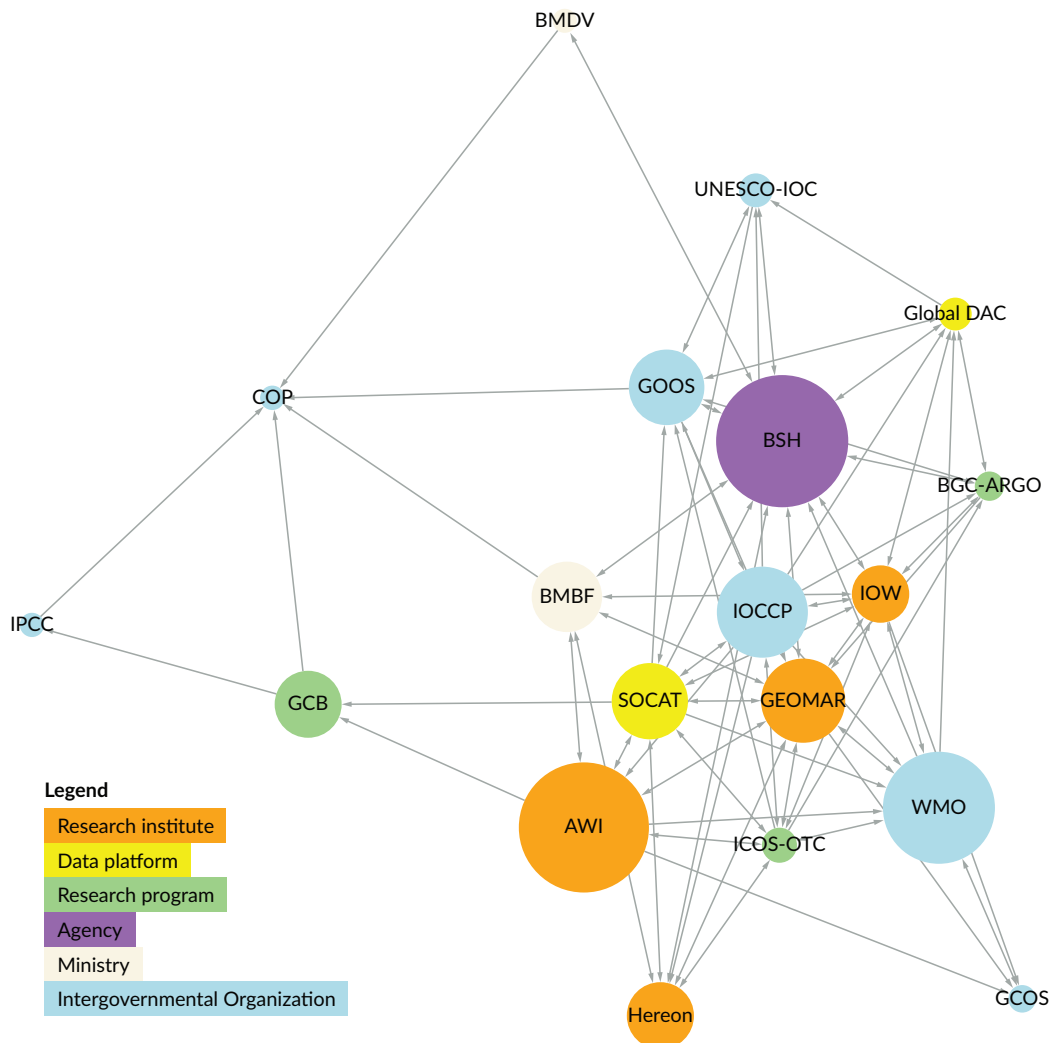
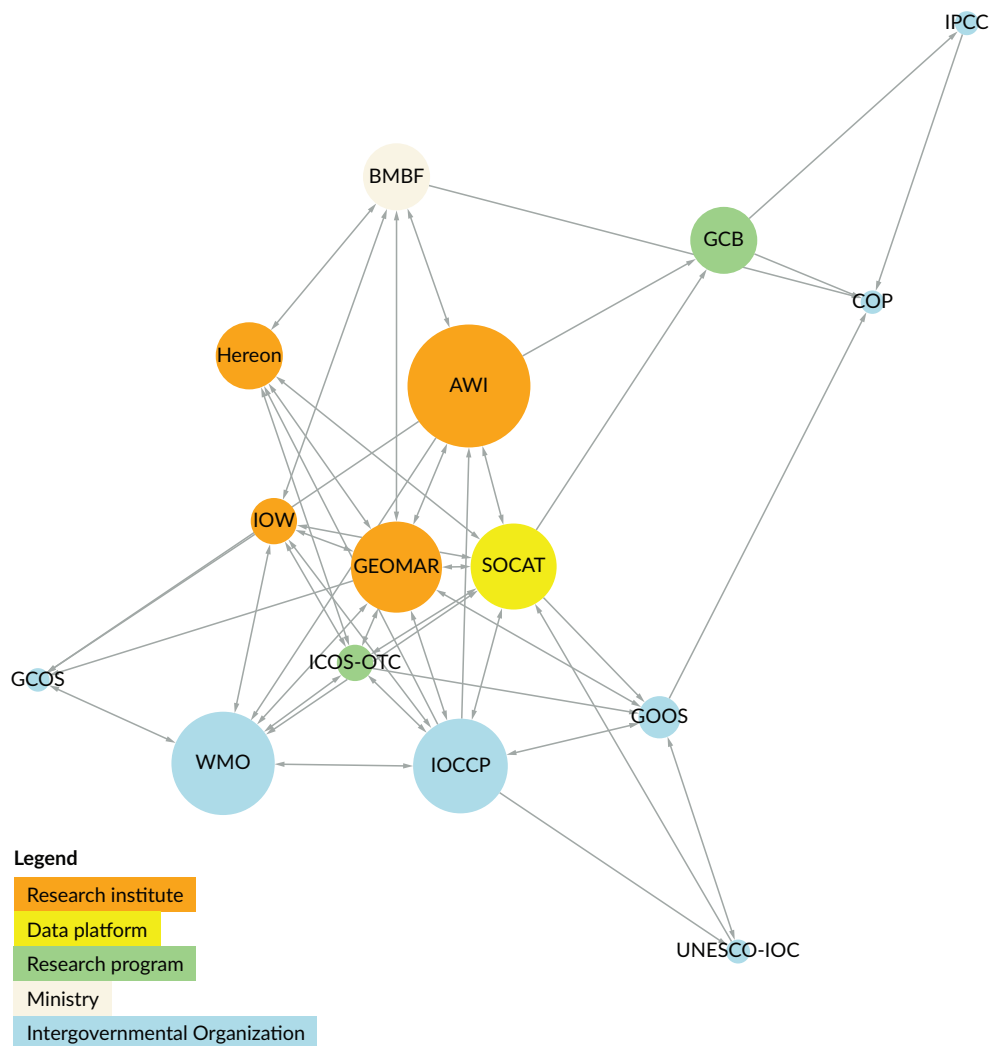**Figure 4.** Full marine CO2 knowledge network. Notes: Size of nodes according to the betweenness values; size of arrows according to the intensity of information exchange.

For example, researchers from GEOMAR, Leibniz Institute for Baltic Sea Research Warnemünde, and BSH are the ones driving forward the integration of MCOs taken at the surface with measurements taken across the ocean column by Argo floats. Similarly, researchers from AWI are involved in marine carbon measurements as well as in modeling activities related to the GCB, connecting actors across the value chain. BSH, as the dedicated marine federal agency of Germany, has strong links to the research community across different observation networks but also to both ministries with tasks and interests related to ocean observations, and to intergovernmental entities such as the IOC where it represents Germany.

The WMO also has a comparatively high betweenness value. This can be explained by its recent initiative to establish a Global Greenhouse Gas Watch monitoring system, of which marine carbon is to be a part, and which led to increasing information exchange with actors in the MCO network. Until now, WMO has mostly been concerned with atmospheric measurements of CO_2, leaving marine measurements largely under the auspices of UNESCO-IOC, although marine carbon parameters are also reported to the Global Climate Observing System. Pushing for a holistic understanding and measurement of the global carbon cycle through one single initiative under the auspices of the WMO points to the fact that roles between WMO and IOC are shifting and that knowledge from the oceanic system is increasingly recognized as directly relevant to questions related to meteorology and climate.

The other body from the UN system with relatively high betweenness values is the International Ocean Carbon Coordination Project as the dedicated coordination and outreach entity for MCOs, connecting to actors conducting and compiling observation data and linking them to the UN system as well. It also has a large number of outgoing ties, illustrating that rather than fulfilling its role by receiving and compiling information, it operates as an entity that spreads news and engages proactively across its connections that succeed in bridging different parts of the network, which our interview data supports. When looking at the network of surface ocean carbon observations only, SOCAT becomes one of the entities with the largest betweenness values, demonstrating its importance for this part of the value chain in connecting individual data points to more aggregated, policy-oriented products (Figure 5).

When assessing homophily in the network, i.e., the extent to which actors are more likely to form ties within a group than across groups, it becomes evident that there are even more connections across different kinds of entities (e.g., research institutes, data platforms, ministries, etc.) than among them. The odds-ratio test returns a value of 1 for equal likelihood, a value between 0 and 1 for a higher likelihood of across-group ties, and a value higher than 1 to infinite for a higher likelihood of within-group ties (Bojanowski & Corten, 2014). For the different kinds of entities in the entire MCO network, the test returns a value of 0.78, and for the surface-only network one of 0.74. This shows that, next to information sharing between entities that likely have similar expertise (e.g., among research institutes), the majority of links tie actors to those that likely have different concerns and priorities (e.g., research institutes to UN bodies, data platforms, research programs, and vice versa) and that subsequently bring different stocks of knowledge to the table, e.g., related to funding priorities and opportunities, political developments at the international stage, etc. The slight heterophily of the network (i.e., the higher likelihood of ties across actor groups rather than within them) also speaks to its ability to move information along the value chain rather than circulating it back and forth within one particular group. When looking at scales (i.e., German, EU, and international) rather than kinds of entities, ties within and across groups are almost evenly split (odds-ratio test result: 1.15 for the entire network and 1.05 for the surface observation only). This demonstrates that actors overall are about as likely to share information with

Figure 5. Marine CO_2 knowledge network for surface observation only. Notes: Size of nodes according to the betweenness values; size of arrows according to the intensity of information exchange.

others that are located at the same scale (i.e., that also form part of the German national science system) as they are with entities at the European or the international level, with a very slight tendency towards sharing information within the same scale if we look at the network in its entirety.

5. Strengths and Vulnerabilities of the Network

Looking at the structural properties of the system in which knowledge on marine CO_2 is produced demonstrates the large extent to which entities across spatial scales and focus areas are engaged in a mutual exchange of information, answering to the coordination challenges posed by a field of study that requires the synthesis of large amounts of single data points collected with various instruments and in diverse geographies. Contrary to the mental image provided by a value chain where information flows in one direction only, knowledge on marine CO_2 is created by a continuous back and forth between the entities located at different stages to ensure that the information provided fulfills the needs of the next aggregation step.

Interviewees unanimously agree that the close ties that actors maintain to others are the clear strength of the network, allowing researchers to minimize transaction costs by coordinating processes (e.g., aligning ICOS data submission requirements and timeline with those of SOCAT), to have an overview of the state of research and new technological developments in their field, and to ensure that the necessary knowledge for international climate policy-making reaches the policy sphere reliably.

However, several interviewees pointed out that the coordination effort that is required remains largely invisible, as standard-setting procedures, intercomparisons of instruments, data quality control, etc., are not, themselves, part of the final products to which they contribute. This lack of visibility is often tied to a lack of dedicated funding. SOCAT, for example, relies almost exclusively on voluntary contributions for its peer-review process of data. It receives no institutional funding, even though the 37.3 million individual measurements that it includes provide the backbone for global assessments of the ocean's function and capacity as a carbon sink. "A lot of it relies on personal conviction," says one researcher (Interview 3), describing how information flow across the network is maintained. Similarly, data management (i.e., the storage of data, its provision in adequate formats, the collection and provision of metadata, etc.), which is essential so that information collected by one entity can be found and used by another, is rarely given sufficient attention by funding organizations or recognition in academic performance metrics (Interview 3, Interview 12, and Observation 3).

As it is rather small, most researchers within the MCO community in Germany have well-established relationships with each other as well as with the representatives of international organizations and, sometimes, even their counterparts at the ministries. Many of the people engaged in the MCO value chain have actively shaped it and therefore also have knowledge about the functioning and operational requirements of other entities. Similarly, people are often affiliated with several entities at once. On the one hand, this eases the flow of information across the network and helps to keep it functional despite the lack of funding for key tasks and entities, as personal ties are often leveraged to solicit voluntary support (Interview 3, Interview 8, and Interview 12).

On the other hand, it also makes the system vulnerable to an extensive loss of institutional knowledge and an increase in transaction costs when people retire, fall ill, etc. (Interview 1, Interview 3, and Interview 11). As a generational change is approaching in many entities, this might pose a significant challenge in the coming years, especially because tasks for which no or very limited funds are available are often taken up by tenured professors whose positions don't rely on the acquisition of research projects (Interview 11 and Interview 12). "Maybe it's our own mistake that we have kept it going like this for so long, giving the impression that it's going well, when really, it is not," one meeting participant says, referring to the extent of voluntary work that goes into maintaining the existing MCO system and value chain (Observation 3). The personal conviction and intrinsic interest of actors within the network to facilitate the flow of information required to maintain the MCO value chain also explains why entities with high betweenness values overwhelmingly use their position to serve as knowledge brokers, as interviews and participant observation demonstrate, rather than as gatekeepers.

As significant and often voluntary effort goes into maintaining data collection and provision in the first place, little resources are left to evaluate and improve the value chain itself. For example, over the last years, the discrepancy between modeled marine carbon uptake and calculations based on data products has increased (Interview 11 and Interview 15). The research community has responded with a bottom-up process to

improve the knowledge about the global carbon sources and sinks on regional levels to support the GCP (see RECCAP2-ocean, n.d.). Yet, the exact causes of the discrepancy and how to resolve it remain unclear as resources to deepen the endeavor are lacking—RECCAP-2 was another largely voluntary effort—and so is international steering (Interview 11).

The reliance on research funding for data collection represents another vulnerability. While technological innovations for measuring instruments satisfy the novelty requirement of research funding, the existing observation system mostly fulfills the purpose of monitoring marine carbon. This requires routine, standardized observations over time and is thus, by its very nature, ill-suited for research funding lines (Interview 4 and Interview 11). Having grown out of novel research and technology at the time, MCOs in Germany and many other parts of Europe are still linked to research funding rather than institutionalized climate monitoring systems. Partly due to this inconsistency, the existing network of SOOP lines maintained by European researchers has shrunk over the last years despite increasing recognition of the importance of integrated carbon observations and the fact that overall coverage of the global ocean surface by MCOs only extends to 2% (Interview 8 and Interview 11).

The positioning of MCOs between monitoring and research with the associated lack of funding security and academic recognition for key tasks also makes it challenging to recruit academic talent. As one senior researcher phrases it: "How can I advise my PhD students to pursue this? Or to put hours of their time into curating data for SOCAT when they have to write publications?" (Interview 12).

The Global Greenhouse Gas Watch initiative and the associated emergence of the WMO as a broker organization is therefore a promising development as, contrary to the UNESCO-IOC, it has the capacity to make binding decisions for its member states, e.g., on the establishment of monitoring networks. Including marine carbon in this initiative potentially represents an important step in shifting MCOs from research funding lines towards institutional ones and in making a steering effort at the international level. Symbolically, it also integrates MCOs more firmly into the climate observation community.

6. Conclusion

This article is the result of an interdisciplinary project aiming to understand how knowledge of MCOs is produced and made available for global policy-making. Starting from the German MCO network, and expanding to the European and international networks into which this is embedded, it provides an innovative perspective on the internal processes through which data from various sources are collected, made comparable, and turned into useful information for the policy process. It demonstrates the large extent of mutual information exchange that occurs within this knowledge system across entities at different scales and with different foci, and the immense and largely invisible coordination effort that it requires. It finds that, to a large part, this coordination effort is borne by entities at the bottom of the value chain, executing and coordinating measurement and data processing procedures so that data from multiple sources and geographies can be integrated and provided in a common format, in one location.

However, our analysis also shows that the knowledge system is vulnerable to fluctuations in funding, especially at the levels of data collection, data provision, and data management. It demonstrates that long-standing relationships facilitate the exchange of knowledge as well as the provision of voluntary support necessary to

cope with, e.g., staff shortages or other systemic bottlenecks. These vulnerabilities have raised acute concerns about the sustainability of the knowledge system in its current form. Policy-makers engaged in the fields of science and/or climate policy thus need to (a) recognize the importance of coordination by ensuring the continued existence of coordination platforms and programs and providing them with sufficient resources, (b) resolve the institutional insecurity of MCOs by supporting the integration of marine carbon into a global greenhouse gas monitoring system, and (c) recognize the importance of data management and provision as a key task, adapting metrics for academic performance and ensuring that sufficient funds are available.

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Conflict of Interests

The authors declare no conflict of interests.

Data Availability

Data collected for this research can be made available upon request with some modifications to guarantee anonymity.

Supplementary Material

Supplementary material for this article is available online in the format provided by the author (unedited).

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"Other(ed)" Ocean Knowledges: Unlearning Integration in Ocean Governance for Recognitional Justice

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Abstract

There is an increasing call for the need to "integrate" Indigenous and local knowledge systems in ocean governance processes, on national and global scales. However, the knowledge systems, epistemes, and practices of different Indigenous and local coastal communities, whose stewardship of the planet sustains and protects marine ecosystems, pre-date the institutionalised ocean sciences and governance with which they are meant to be integrated. The concept of integration often perpetuates othering and devaluation of various ocean knowledges that should not be subject to these problematic practices. Much of the current knowledge informing ocean governance is underpinned by colonial, military, and financial projects, in direct juxtaposition to epistemes and practices that are deeply interconnected with marine life. Writing from a marine social sciences perspective, we explore the inherent problems and limitations of integration approaches and propose reversing how we frame "knowledge" and its othering by suggesting that our scientific and governance practices are, in fact, "other" to longstanding ways of coexisting with the ocean. Without attempting to represent Indigenous knowledge systems or categorise these as unaware of scientific developments, we argue that researchers and scientists need to actively unlearn what is taught in prominent ocean sciences. By focusing on global governance through the International Seabed Authority and national ocean governance in South Africa, respectively, we explore knowledge othering and the process of unlearning what ocean governance teaches as knowledge integration to better critically consider how the ocean is, has been, and should be valued.

Keywords

knowledge integration processes; ocean knowledges; ocean governance; othering; recognitional justice; unlearning

1. Introduction

There is an increasing call for the need to integrate Indigenous and local knowledge systems in ocean governance processes on local, national, and global scales. In this article, ocean governance refers to decision-making processes regarding a specific marine area and it can be understood as various approaches to "sustainably" managing the ocean. Recently, there have been calls for *transformative* ocean governance, which can be understood as more integrative and inclusive ocean decision-making processes (Erinosho et al., 2022). There is a growing recognition that we cannot solve the complex sustainability challenges facing our environment, including our ocean, without considering multiple ocean knowledges, particularly recognising Indigenous knowledge systems and traditional ecological knowledge (Chilisa, 2017; Mulalap et al., 2020; Vierros et al., 2020). However, how this knowledge integration should take place and what it should look like is continuously discussed and contested (Strand et al., 2022; Zeigermann, 2021), and several critiques of knowledge integration practices suggest that they do not adequately consider existing power asymmetries and knowledge hierarchies (Chilisa, 2017; Niner et al., 2024; Reid et al., 2020; Stein et al., 2024), therefore entrenching or upholding these unequal power relations (Bohensky & Maru, 2011; Nadasdy, 2007). In this article, we purposefully refer to the plural "knowledges" to unlearn the structural and western understanding of single knowledge and challenge the western hegemonic understanding of knowledge production.

To integrate (n.d.) is defined by the Cambridge Dictionary as follows: "to mix with and join society or a group of people, often changing to suit their way of life, habits, and customs" or "to combine two or more things in order to become more effective." As emphasised by Bohensky and Maru (2011, p. 1), knowledge integration can be understood as "incorporating new information into a body of existing knowledge," which begs the questions: "Whose knowledge is 'new,' whose is 'existing,' and who decides? Current integration efforts for ocean governance often consider the combination of various sciences (such as natural and social), or the combination of marine sciences and Indigenous knowledge systems. As emphasised by Godemann (2008), knowledge integration involves the process of drawing together diverse knowledge bases and disciplines to address complex problems or develop comprehensive solutions. The idea is that being open to a greater ecology of knowledges does not require a discrediting of scientific knowledge or western ideas of rationality (Mazzocchi, 2018) and that there are similarities between Indigenous knowledge systems and marine sciences in the way they speak about overlapping environmental, social, and intellectual spaces.

Critiques of knowledge integration, however, emphasise that Indigenous knowledge systems are not products that can be packaged to "fit" the status quo, that they can be misused and misappropriated and that the term knowledge integration is often used tokenistically to argue that Indigenous peoples have been considered as a part of ocean governance processes (Chilisa, 2017; Latulippe & Klenk, 2020; Reid et al., 2020). Nadasdy (1999, p. 1), emphasises that one of the problems with the idea of integration is the "implicit assumption that the cultural beliefs and practices referred to as 'traditional knowledge' conform to western conceptions about 'knowledge.'" Indigenous scholars and scientists have also pointed out that climate change and ecological challenges are rooted in "colonial patterns of relationship" and the ways in which the universalisation of western ways of being and knowing have been imposed (Stein et al., 2024, p. 2; see Davis & Todd, 2017; Hernandez et al., 2022). Throughout this article we use "western" to refer to the spaces created within what Shahidul Alam coined in the early 1990s as "Minority World": "'The Minority World' is a shorthand term for those people, wherever in the world they are, who fall into the top percentage of indicators for income and other indicators of wealth and wellbeing" (Oppong & Dombroski, 2024, p. 116).

We aim to mostly use Majority and Minority Worlds throughout, but at times might keep western (with a lowercase) when suggesting that a construct is part of an antiquated understanding of the word. We find the expression Majority and Minority Worlds more apt as it does not divide the globe by hemispheres, or development indicators, which designate parts of the world through a metric that reduces people and communities to only numbers and data, though any division of the world always has limitations:

> In short, "Majority World" refers to the majority of people in the world, who live in previously colonised, lower and middle-income nations, but who do not have access to the elite lifestyles of the richest people in their home countries, or elsewhere in this globalised world. "Minority World" refers to the minority of people in this world, including those who live in high-income countries and also those who have access to elite consumerist lifestyles from anywhere in the world. (Oppong & Dombroski, 2024, p. 115)

There is a need to better consider and address who holds power in knowledge integration efforts, as well as the context in which knowledge integration is being considered. In fact, the process of integrating various ocean knowledges, such as Indigenous knowledge systems, into top-down, didactic, positivistic knowledge hierarchies can perpetuate epistemic and recognitional violence, and uphold processes of othering. Othering refers to creating or perpetuating a conceptual difference between us and them (Said, 1978). It is the subsequent distancing or distinction between an "in-group" and "others," which has been used to subjugate countries, cultures, populations, and knowledge systems (Spivak, 1985). "Others" are characterised by their difference (often expressed through opposite or conflicting binaries). In the context of colonialism and coloniality, such as through development aid discourses from the Minority World to the Majority World, for example, othering has been expressed through binaries where the latter "have been defined by notions of their 'Southern' uncivilised, backward, cultural and/or traditional nature, in comparison with Western and Northern societies' civilised, progressive, scientific and modern nature" (Strand, 2022, p. 366).

By not recognising that it may be western academic marine sciences that are "the other" (Spivak, 1985), and continuing to highlight Indigenous and local knowledge systems as "other ways of knowing," we are upholding "unequal power relations between Western and non-Western knowledge" (Chilisa, 2017, p. 815), and reinforcing colonial structures and legacies. Without adequately considering and deconstructing the ways in which western, Eurocentric knowledge has suppressed (and continues to suppress) Majority World's knowledge, we are inadvertently supporting knowledge hierarchies in which certain ways of knowing are seen as more valuable, credible, and legitimate than "others." In this view, knowledge integration efforts can perpetuate othering of various ocean knowledges by supporting existing Eurocentrism and academic imperialism by inadvertently proposing "assimilation" (Reid et al., 2020). Academic imperialism is defined by Chilisa (2017, p. 814) as "a practice where conceptual and theoretical frameworks, research questions, research designs, and research techniques that stem from the developed world continue to promote the European/western thought systems and build deficit theories that perpetuate distortions of African experiences.''

Although it is not new to point out the dangers of knowledge integration, we continue to see this practice being perpetuated in ocean governance processes without adequate scrutiny and attention to how this can reinforce coloniality and othering. This is also the case for governance overall, given that global, and most local, systems are grounded in what Adébísí (2022, p. 25) calls "Euro-modern law," which:

Was and is necessary for the continuation of colonial legacies…through its role in naturalising the orders of power already laid down…yet, this world it makes is also characterised by the reproduction of extreme, manufactured inequality and the acceleration of ecological disaster.

This is the case for ocean governance as well; indeed, 20 years ago, Mansfield (2004, p. 313) argued that neoliberalism was becoming the "dominant mode of ocean governance" through its focus on marketisation and privatisation, and Winder and Le Heron (2017, p. 4) emphasise that the blue economy can be recognised as a "neoliberal governance regime." Instead of seeing the ocean as part of our social-ecological system, it has become characterised as something to be "managed, allocated and developed as property, and governed through market mechanisms" (Winder & Le Heron, 2017, p. 4).

For this reason, this article explores problems with knowledge integration in the context of marine spatial planning (MSP) in South Africa and the International Seabed Authority negotiations for a regulatory framework for deep-sea mining (DSM). We propose reversing how we frame "knowledge" and its othering by suggesting that our scientific practices are "other" to longstanding ways of coexisting with the ocean. Indeed, as some have argued, ocean sciences are deeply entangled with colonial, mercantile, and military projects, and they are often funded through the corporate world (see Dutt, 2020; Elias, 2019; Hardy & Rozwadowski, 2020; Oreskes, 2021). Moreover, we cannot claim to resist othering and knowledge hierarchies without considering and reflecting on our own positionalities and biases. Writing from a marine social sciences perspective, identifying as two women trained in largely western institutions and now residing in the UK and South Africa, we recognise the limitations of our White European positionalities in what we can and should argue, and even how our positionality statement can perpetuate manifestations of coloniality (Gani & Khan, 2024). From our own experiences as researchers, scholars, and ocean enthusiasts, continuously benefiting from coloniality, but seeking equity and anti-coloniality through our work, we have both experienced a recurring encounter with knowledge depreciation, devaluation, and othering of "non-academic" knowledge systems that should be represented, respected, and recognised equitably in ocean governance processes. Departing from these motivations and positionalities, we therefore explore the inherent problems and limitations of integration approaches and discuss opportunities for advancing pluriversality and recognitional justice. Without attempting to represent or speak for Indigenous peoples or Indigenous knowledge systems, we argue that we as western-trained scholars need to actively unlearn what is taught in prominent ocean sciences. By focusing on two examples of ocean governance processes with which we are personally and professionally familiar—namely, the International Seabed Authority and MSP in South Africa—we consider examples of knowledge othering and explore practices of unlearning knowledge integration processes in ocean governance to better critically consider how the ocean is, has been, and should be valued.

2. Theoretical Framework

2.1. Othering of Ocean Knowledges

Othering is a process of conceptualising an in-group, emphasising that "others" are not included because they are characterised by their supposed difference (often culturally constructed), often highlighted through dimensions such as space and knowledge (Spivak, 1994; Strand, 2022). Othering through space refers to the representation of an "other" that is far away, distanced, and different from the supposedly progressive, enlightened, and modern west (Said, 1978). At the core of this theory is the conceptualisation that you cannot

identify yourself without characterising the other (Feierman, 1993), and this othering often takes shape in collective notions identifying Europeans as "us" against non-Europeans as "others" from different geographies and cultures. This othering can be argued to extend to the invention of the "Third World" (Escobar, 2012), which conceptualised it as something that needed outside intervention from the thriving and developed "First World" during imperialism and colonialism.

There is also a process of othering through knowledge hegemonies and hierarchies. As emphasised by Foucault (1980), there has been a claim of a "unitary body of theory" which omits, devalues, and disqualifies knowledges that do not fall within its metrics or frames. This othering through knowledge valuation is often termed "Eurocentrism" and is the thought that knowledge produced in Europe is the only source of universality and truth (Grosfoguel, 2009; Strand, 2022). Knowledges not framed within a Minority World point of view are deemed illegitimate and have through history been buried, disguised and discredited, and silenced (Chilisa, 2017; Ndlovu-Gatsheni, 2019). Chilisa (2017, p. 813) emphasises that in sustainability science, Indigenous knowledge "is sometimes relegated to 'junk status' through narratives of 'backward,' 'irrelevant,' superstitious, and inferior knowledge which is 'less' than Western Science and harmful to the environment." Trends in knowledge hierarchies can also be seen in marine sciences today, through statistics on the lack of representation of top publishing scholars in climate change and ecology from the Majority World, and an even more striking underrepresentation of women of colour (Maas et al., 2021; Schipper et al., 2021). Lobo and Parsons (2023, p. 128) emphasise that sustainable development goals, climate change agreements, and laws of the sea have attempted to transform "dystopic planetary futures through openness to Indigenous and local knowledges" without recognising that "Indigenous, Black, Brown, and southern intellectual traditions of belonging and responsibility in settler colonial, postcolonial, and post-apartheid societies have always existed alongside White, western Euro-American ontologies of the ocean." There is also the continued phenomenon of helicopter and parachute science, where marine scientists (mainly from the Minority World) extract knowledge and data from contexts (mainly in the Majority World) without recognition of or benefit to the knowledge holders in the local communities themselves (Adame, 2021). Therefore, when ocean sciences claim to be objective, neutral, and universal, they are not when we consider whose voices, lived experiences, and situated knowledges are informing them and whose are not.

All dimensions of othering are interlinked, and they are often perpetuated through binaries and dichotomies that classify human beings according to "invented racial categories" (Said, 1978; Strand, 2022). Building on the argument made by Chilisa (2017), knowledge hierarchies are often played out through dichotomies such as "relevant" vs. "irrelevant," "subjective" vs. "neutral," "backward" vs. "progressive," and "superstitious" vs. "science-based." In marine sciences today, we find there is often a juxtaposition between "science" and "Indigenous knowledge systems" or "traditional knowledge." This is emphasised through the increasing push to integrate Indigenous and local knowledge systems in marine sciences, thus assuming they are inherently different—and that one enjoys a higher status than the "other." Shizha (2010, p. 115) argues that the academic system has been "created as the epicentre of colonial hegemony." Instead of calling for the reinvention or deconstruction of hierarchical, colonial, and Eurocentric research methodologies and research approaches, knowledge integration tends to perpetuate and reinforce existing epistemologies and worldviews rooted in western and Minority World knowledge hierarchies and othering. This means that integration efforts may not be enough, and Wilson (2008, p. 41) argues the need for an Indigenous paradigm, stating that:

We have tried to adapt dominant systems research tools by including our perspectives into their views. We have tried to include our cultures, traditional protocols and practices into the research process through adopting suitable methods. The problem with that is that we can never really remove the tools from their underlying beliefs.

2.2. Integration as Recognitional Injustice

Integration is often framed as a positive concept in ocean sciences and governance, a process that can bring together various ways of knowing the ocean and various sectors and stakeholders with an interest in ocean governance (Winther et al., 2020). Since the late 1990s, integrated ocean management has been celebrated as the ultimate approach to ocean governance, as the limitations of sector-based approaches became evident (Cicin-Sain & Knecht, 1998). However, in recent years, the need to pursue social-ecological systems approaches, that see humans and nature as intrinsically linked, has to some extent replaced the dominance of integrated ocean management, although perhaps more in theory than in practice. Concerning ocean sciences, the push for knowledge integration has received similar attention since the 1990s, particularly the need to integrate natural and social sciences, marine sciences, and Indigenous knowledge systems.

Although we do not dismiss that knowledge integration is important for holistic approaches to ocean governance, we argue that there is a need to adequately deconstruct and address existing power structures and dynamics that impact what role, sovereignty, and legitimacy specific knowledges and knowledge systems enjoy in these processes (Chilisa, 2017; Wilson, 2008). Continuing with knowledge integration for ocean governance in the status quo, we ascertain, can perpetuate or lead to recognitional injustice, particularly when these processes are often, like climate policies, "designed with the intention of trying to 'incorporate' limited elements of Indigenous thinking into an established non-Indigenous framework" (Deranger et al., 2022, p. 52).

Recognitional ocean justice refers to the equitable acknowledgement and realisation of people's rights, of people's values, livelihoods, knowledges, lived experiences, narratives, and worldviews (Bennett et al., 2021; Lau et al., 2021). It refers to identifying and questioning whose interests, worldviews, and identities are currently valued, respected, and legitimised (Lau et al., 2021), and pursuing recognitional equity by prioritising the rights, interests, and identities of people that have historically been devalued, disrespected, and delegitimised through ocean governance processes (Strand, 2023). Recognitional justice is different from the politics of recognition, which in some instances, similarly to positionality statements, have been found to reproduce colonial power structures by assuming or reinforcing the superiority vs. inferiority binary (Coulthard, 2014). Rather, recognitional justice involves cognitive justice, as adapted from Amadiume (1997) and Bhargava (2013), which can be understood as occurring when people are governed and understood by how they self-identify and self-categorise the world around them. To reach recognitional and cognitive justice, we therefore need to elevate ocean knowledges that have been, and continues to be, silenced, excluded, and devalued (Strand, 2023).

Currently, ocean governance processes such as MSP, marine protected areas, and conceptualisations and applications of the "blue economy" can lead to recognitional injustice by denying the rights and livelihoods of Indigenous peoples and local communities across the globe (Bennett et al., 2021; Lobo & Parsons, 2023; Mulalap et al., 2020; Okafor-Yarwood et al., 2020; Sowman & Sunde, 2018; Vierros et al., 2020;). There are

varying examples of local coastal communities experiencing ocean grabbing, bereavement of customary fishing opportunities, and disregard for the values that they attach to ocean spaces (Mulalap et al., 2020; Vierros et al., 2020). Chilisa (2017, pp. 814–815) points out that "the unequal power relations between European/Western knowledge and other knowledge systems poses a threat to meaningful integration." The aspect of knowledge integration can therefore lead to recognitional injustice, which is already emphasised by Lau et al. (2021, p. 2) stating that the "pursuit of benefit sharing in conservation projects in developing countries (i.e., distributional justice) often requires groups to assimilate dominant discourses related to human–nature relationships, leading to recognitional injustice."

In this article, we argue that the continued push for knowledge integration in both legal frameworks and ocean governance processes, such as the MSP and within the International Seabed Authority's work, are in danger of perpetuating recognitional and cognitive injustice by failing to deconstruct existing coloniality of knowledge and knowledge hierarchies (see Niner et al., 2024). As White/European scholars, we reflect on our complicity in these processes, and we discuss how centring, unlearning, and advancing pluriversality can assist in deconstructing existing othering processes of ocean knowledges in ocean governance.

2.3. Advancing Pluriversality Through Unlearning

Unlearning can be understood as learning to unlearn, which is conceptualised by Tlostanova and Mignolo (2012, p. 7) as "to forget what we have been taught, to break free from the thinking programs imposed on us by education, culture, and social environment, always marked by the Western imperial reason." Closely linked to this are the ideas of "unthinking" and "rethinking thinking," which can be understood as radically revising and sometimes even discarding many of the presumptions that remain the foundation of dominant perspectives today (Ndlovu-Gatsheni, 2019). In the context of ocean governance, unlearning what we know is the process of continuously questioning and critically examining whose values, norms, knowledges, interests, and onto-epistemologies are informing dominant ocean decision-making, science, and research (Lau et al., 2021, p. 2; Moon et al., 2021), instead of taking ocean governance processes and theories for granted. Circling back to the concept of "knowledge integration" for ocean governance, we could even reverse how we frame "knowledge" and its othering by suggesting that our own scientific practices are, in reality, "other" to longstanding ways of coexisting with the ocean.

This is particularly important in the context of environmental management and ocean governance, as we need to undo the human–nature divide that continues to promote the belief humans are superior to nature and that we should, therefore, control and exploit it. For instance, Ferdinand (2019, p. 30) argues that thinking ecologically from the Caribbean means undertaking an epistemic shift in the scene of knowledge and discourse production. This argument can also be found in Gumbs' (2020, p. 9) call for "undoing a definition of the human, which is so tangled in separation and domination that it is consistently making our lives incompatible with the planet."

One aspect of pursuing this unlearning is critically deconstructing existing methodological hegemonies in the marine and sustainability sciences. As argued by Chilisa (2017, p. 814), "there is a need to reclaim space for Indigenous epistemologies and methodologies in the global knowledge system." We argue that one way of approaching this, from our positionalities as European-born, White, marine social scientists, is to actively attempt to unlearn and deconstruct colonial knowledge hierarchies, unmask our implications in these knowledge hierarchies through processes such as knowledge integration, and posit our own knowledge

systems as "other" to Indigenous knowledge systems that have been co-living with the ocean for centuries, without essentialising or romanticising them. Indeed, we are not suggesting that all individuals must undertake this work independently, but rather we are doing this here in the hope to begin conversations about how unlearning could become a systemic practice at broader levels than simply the individual one. We do not expect that our approach here is necessarily the "right" one, but we see it as forming part of a wider engagement with this type of work. We need to reveal, deconstruct, and unlearn methodological hegemonies, which have a "tendency to perpetuate the dominance of one race over the 'other' by building a collection of theories, concepts, methods, techniques, and rules designed to promote only the knowledge that promoted and profited Eurocentrism" (Chilisa, 2017, p. 814, 2020).

To initiate this unlearning, we suggest the following actions; (a) Critically consider suggestions for knowledge integration in ocean governance processes, actively questioning and addressing what "knowledge" is being integrated into what "knowledge-framework," and whether this is possible without reinforcing coloniality of knowledge and recognitional injustice; and (b) To the extent possible, continuously unveil existing structural processes that uphold and perpetuate knowledge othering, such as the push for one-size-fits-all or nation-wide ocean governance processes that are not adapted to context, are tokenistic or lack representation of various knowledge systems in ocean governance processes, or pay inadequate attention to existing power asymmetries between knowledge systems. This work includes making visible "racial injustice, climate colonialism, capitalist extractivism, and multispecies extinction with material consequences" (Lobo & Parsons, 2023, p. 130) present in current ocean governance processes and regimes.

Ideally, we do not need to frame any knowledge as "other," and we should rather promote equal, or equitable, knowledge valuation. This could be advanced by embracing pluriversality, which is the dismissal of universal or objective knowledge, and the celebration of the diversity of ways of knowing and understanding the world. It can be understood as a process of "deconstructing the myth of universality" (Gwaravanda & Ndofirepi, 2021, p. 57), by recognising that all knowledges are underpinned by different cultures that are neither universal nor hegemonic (Mignolo, 2000). Pluriversality is often traced to the Zapatista movement in Mexico, calling for "a world in which many worlds would coexist" (Mignolo, 2018, p. IX), and to better advance ocean pluriversality we suggest that we, as marine researchers, should be guided by a "desire to produce waves of more diverse citational politics that privilege Indigenous, Black, Brown, and Southern-led ontologies of the ocean" (Lobo & Parsons, 2023, p. 130). We should be scrutinising our own citation biases and practices, and rather actively citing and elevating formerly and currently silenced voices and narratives in our ocean governance research, engagements, and recommendations.

3. Case Studies

3.1. Integrating Knowledge in South Africa's MSP Process

MSP refers to an approach to ocean governance and the ways in which a country or entity decides to plan, organise, and manage marine spaces. MSP approaches have often been celebrated for their role in promoting sustainable blue development by recognising and integrating multi-sectoral interests (Flannery et al., 2019), but a growing body of research criticises MSP for inadequately incorporating and recognising Indigenous and local knowledge systems, from planning to implementation (Kidd & Shaw, 2014; Okafor-Yarwood et al., 2020; Saunders et al., 2020).

In the South African context, the government is currently in the process of implementing an MSP framework that aims to recognise social, economic, as well as ecological needs and priorities, and integrate various knowledge systems to achieve a "sustainable blue economy" (Department of Environmental Affairs, 2017). MSP was initiated in 2014 with the launch of Operation Phakisa (*phakisa* meaning "hurry up" in Sesotho), with a focus on "unlocking" the economic potential of the ocean. MSP was seen as a key component of this goal by providing an "integrated governance framework" (Dorrington et al., 2018). The MSP Act (Republic of South Africa, 2019) was signed into operation in April 2021, and it states that future marine area plans should consider "the community and cultural values," "shared economic, cultural, social and environmental values," and "the current and future needs and related priorities" (Republic of South Africa, 2019, pp. 8–10).

Despite this recognition of integrating various knowledge systems and accounting for community values into the MSP process, Indigenous knowledge holders continue to express that they have been excluded from ocean decision-making in the country (Rivers et al., 2023; Strand et al., 2022). Both the MSP process and other area-based ocean management approaches have, instead, been characterised by top-down decision-making and tick-box stakeholder engagement, without meaningfully engaging with Indigenous peoples and local communities to include their priorities, knowledge systems, and ocean connections (Rivers et al., 2023; Sowman & Sunde, 2018). It is important to note that the reference to Indigenous and local knowledge systems and knowledge holders in South Africa is to recognise that in many local contexts, such as in Algoa Bay, there has been "a blending or merging of cultural values, kinship and practices between Indigenous Khoi and San, the amaXhosa, amaZulu, and other ethnic groups of South Africa such as the Cape Malay, Indian, Dutch, Afrikaans and English communities", where the latter have been settling in the area since the early 1500s (Strand et al., 2022, p. 3).

As a researcher that has personally been part of the calling for better knowledge integration in the MSP process (Rivers et al., 2023), I (Mia Strand) am now reflecting on my implication in inadequately considering aspects of knowledge othering, representative injustice, and pluriversality in these processes.

Firstly, we, therefore, question the overarching oceans economy approach to MSP in South Africa, and how the proposed work of "integrating" various knowledge systems into this paradigm may be perpetuating recognitional injustice and reinforcing othering of knowledge systems that embrace a greater, interdependent systems approach to coexisting with the ocean. For example, the ahistorical characterisation of blue economic opportunities underlying the MSP process naturalises the difference between people benefitting and people not benefitting from ocean governance processes. As pointed out by Erwin et al. (2022, p. 384): "In the blind rush for the dream of GDP growth, policy and governance frameworks may exacerbate historic and contemporary socio-economic exclusions. In South Africa capitalist and environmental conservation endeavours can, and have, caused harm for already marginalised people."

By inadequately acknowledging, and addressing, colonial and apartheid legacies on the current ways in which people disproportionately enjoy benefits from and inclusion in the ocean's economy (Clark & Cisneros-Montemayor, 2024), particularly in a South African context (Erwin et al., 2022; Sowman & Sunde, 2018; Strand et al., 2022), we justify and legitimise these inequitable governance processes by arguing that we should "integrate" Indigenous knowledge systems into MSP instead of re-imagining or co-creating new South African ocean paradigms altogether. In the context of Indigenous histories and knowledges, Bam and Muthien (2021, p. 4) argue that the task of attaining cognitive and restorative justice in South Africa includes

"to know the truth of over 300 years of colonial oppression, enslavement, land dispossession, economic exploitation, violence and consequent losses over deep time." Without recognising these truths and historical impacts on what is now portrayed as integrated ocean governance, will the project of "integrating" Indigenous knowledge systems not become extractive instead of inclusive?

Secondly, we attempt to unveil the structural exclusion of ocean knowledges being reinforced through the current MSP process. Instead of seeing MSP as the problem, we can, through greater scrutiny of the underlying processes underpinning MSP, rather emphasise that this approach to ocean governance is a vehicle through which this knowledge othering is perpetuated. The continued exclusion of Indigenous and local knowledge systems in the MSP process also contributes to the silencing and discrediting of lived experiences and knowledge systems alongside the perpetuation of Minority World hegemony. By failing to ensure that Indigenous knowledge systems are directly informing what ocean governance processes look like, how we are defining "sustainable blue development," or why we are prioritising marine protected areas for ocean conservation, MSP processes are effectively devaluing South African knowledges, traditions, and cultures through their "integrated" ocean governance processes (Strand et al., 2022). This is particularly true when Indigenous knowledge systems are portrayed as something that can be extracted from its particular context without considering how these knowledge systems can only enjoy equitable representation through meaningful involvement of Indigenous knowledge holders. The journey towards recognitional and cognitive justice therefore needs to actively recognise and elevate people, ocean knowledges and ocean cultures that have not as yet been part of developing the current MSP narrative.

3.2. The Mining Code of the International Seabed Authority

Moving to a global context, here we think about the International Seabed Authority's creation of a regulatory framework to mine polymetallic nodules in the Clarion-Clipperton Zone. This framework, also called "the mining code" (shorthand used hereafter), organises and codifies how the activity of DSM will take place. The negotiations for this framework take place during the council meetings of the Authority, which happen between 2 to 3 times a year in its headquarters in Kingston, Jamaica. Only countries who are signatories to the UNCLOS have decision-making powers in these negotiations, though other countries, such as the US, and many inter- or non-governmental organisations are allowed to make interventions as "observers" (see International Seabed Authority, n.d.-a, n.d.-b, for more details about signatory nations and observers). Because the Authority is negotiating the mining code, mining cannot yet take place at an industrial scale and companies, sponsored by countries, can only apply for exploration licences. Currently, 32 countries have declared their support for either a precautionary pause, a moratorium, or a ban on DSM; this means that they believe that the process should either be slowed down, for science to provide more evidence on the environmental impact of DSM, or that they are opposing DSM in different forms (see Deep Sea Conservation Coalition, n.d.). The International Seabed Authority as a body, and the negotiation process, are very complex and technical, which means that countries, NGOs, and different actors involved need to bear in mind many issues that cannot be detailed exhaustively in the scope of this article (see Morgera, 2024, for more on the Authority workings and Indigenous communities' participation).

Here, we explore only one regulatory clause within the draft under negotiation at the Authority. We suggest that the legal language used in the mining code, itself building on UNCLOS, is embedded and underpinned by colonial and imperial histories and practices and thus does not permit any space for Indigenous knowledge

systems to be integrated into international governance. UNCLOS is a legal text that objectifies the ocean and codifies how we may extract and exploit it, and though it may require signatories to have some form of responsibility, many of these articles are ambiguous at best (Armstrong, 2022; Ranganathan, 2019).

Here the focus is on how "in/tangible" underwater cultural heritage is being mentioned and articulated within the mining code. This formulation has specific genealogies that need to be unpacked, and which themselves are grounded in western understandings of heritage and tangibility. Indeed, legally it is grounded in both the UNESCO 2001 Convention on the Protection of the Underwater Cultural Heritage and the UNESCO basic texts of the 2003 Convention for the Safeguarding of the Intangible Cultural Heritage (see Forrest, 2002; Khakzad, 2014; Perez-Alvaro, 2023). Indeed, the 2001 Convention does not include the terms "tangible" or "intangible," but the terminology "in/tangible" underwater cultural heritage is being used in International Seabed Authority negotiations. This is in part because under UNCLOS article 149 there is an obligation to protect archaeological and historical objects, and, because one of the Authority intersessional working groups was tasked in March 2023 to consider whether, and how, "in/tangible" underwater cultural heritage could be integrated within the mining code. Intersessional working groups meet remotely between Council and Assembly Meeting sessions, and this particular group is led by Clement Yow Mulalap, adviser to the Permanent Mission to the UN for the Federated States of Micronesia. Since the group first met, they have debated what "in/tangible" underwater cultural heritage might mean (International Seabed Authority, 2023) and whether it is indeed the burden of the mining code and the obligation of the Authority to protect it in the first place, given that the International Seabed Authority mandate is on mining, as the first article of UNCLOS reminds us (UNCLOS Article 1(1)). This has resulted in a rephrasing of "in/tangible" underwater cultural heritage into "human remains of an archaeological or historical nature, or any object or site of a similar nature" (International Seabed Authority, 2024). A formulation grounded in UNCLOS Article 149, as the term "heritage" in UNCLOS only appears as part of "common heritage of mankind", which has different meaning than the UNESCO's definition of cultural heritage. Though regulation 35.2 has kept a mention of "in/tangible" underwater cultural heritage as per the UNESCO definition.

On the one hand, the term "intangible" is problematic because it considers, from a Minority World perspective, certain elements of heritage as immaterial. Indeed, the term intangible automatically makes this heritage invisible and absent, and the Indigenous communities' representatives have raised this issue. On the other hand, this term has allowed for widening the scope of the mining code as its ambiguity and lack of clear legal definition permitted the knowledge and practices of Indigenous communities' representatives to be embedded within the mining code. Another set of issues, however, is the attempt to restrict the formulation of "in/tangible" underwater cultural heritage to refer only to material and tangible objects and sites. This limits ways to protect what pertains to Indigenous knowledge systems and practices and may be perceived as "intangible" from a Minority World perspective. Additionally, the deletion of the term "culture" further suggests that specific institutions—history and archaeology—have the tools to designate what is to be saved. It is worth noting that the term "culture" itself, stemming from a Minority World perspective, can be seen as problematic too given that culture is very much a construct that through binary thinking and othering has often been opposed to "nature" and communities who have been deemed uncultured or uncivilised. Moreover, these two disciplines, history and archaeology, and their frameworks have specific colonial entanglements (Satia, 2020) that underpin them today and this begs the question about the bias their practices may have in deciding what is an "object" and a "site," and whether we deem them "significant." To exclude different Indigenous communities' understandings of "culture" (whether tangible or intangible)

leads to recognitional injustice. As Solomon Kahoʻohalahala (26 July 2023), from the Maunalei Ahupuaʻa/Maui Nui Makai Network in Hawaiʻi has noted repeatedly, when taking the floor at International Seabed Authority Assembly and Council meeting sessions and intersessional working group meetings, there are problems in deleting the term intangible from the mining code, which would erase an albeit imperfect signifier holding a place in a regulatory framework for Pacific cultures:

> I challenge the perception that culture can only be tangible artefacts. As seafaring people, we have travelled across the vast Pacific, the largest ocean on earth. Our observations are intimate experiences and knowledge collected and committed to memory over generations…we are the culture of the people of the deep sea and our culture is intangible. The ocean is everything to us. It's what we connect to and depend upon for our sustenance and our survivability.

Given the complicity of UNCLOS language with territorialisation and the spatial ordering of the ocean for exploitation, sustainable or otherwise, can this same language be the one through which we steward and protect the ocean in an integrated manner, one that includes "other" epistemes and formulations othered by Minority World understandings? What happens if we integrate Indigenous knowledge systems within a colonial framework that needs to be rewritten in the first place (see Ranganathan, 2019, 2023)? More work needs to be done to address these questions, but a short answer is that in order to achieve recognitional justice, integration is insufficient, and it instead undermines the whole process. What is needed is a rethinking of international governance given that, as Anghie (2004, p. 3) notes:

> Colonialism was central to the constitution of international law in that many of the basic doctrines of international law…were forged out of the attempt to create a legal system that could account for relations between the European and the non-European worlds in the colonial confrontation.

4. Conclusion

In this article, we have reiterated existing critiques of knowledge integration and posited these in the context of ocean governance processes. We have argued that, in some instances, we need to unlearn knowledge "integration" as otherwise this can lead to the othering of various ocean knowledges and perpetuate inequitable knowledge hierarchies. An important place to start is to interrogate who holds power in knowledge integration processes, and what knowledge or information is sought to be integrated and why. By discussing existing theories of othering, we consider how knowledge integration processes are in danger of perpetuating this practice. Instead of calling for the deconstruction and reinvention of hierarchical and colonial research methodologies and research approaches, knowledge integration tends to perpetuate and reinforce existing epistemologies and worldviews rooted in the Minority World. We, therefore, argue that knowledge integration in ocean governance is at risk of resulting in recognitional injustice, understood here as the unequal and inequitable realisation of people's rights, values, knowledge systems, worldviews, and lived experiences.

By centring processes of unlearning, understood as breaking free of what we may have been taught in our western academies and radically revising presumptions which underpin existing ocean governance processes (such as extractivist and blue economy paradigms), we have an opportunity to unmask and identify existing othering processes. For example, we suggest that we, as marine researchers, should critically consider

whether knowledge integration efforts are possible without reinforcing coloniality and making visible existing injustices in ocean governance processes, such as the continued exclusion of Indigenous peoples and Indigenous knowledge systems in ocean policies.

We have considered two ocean governance processes with which the authors have personal and professional experiences, namely the MSP process in South Africa and the mining code of the International Seabed Authority, and we have reflected on how we may be complicit in problematic knowledge integration processes. One of the key lessons emerging from reflections on both case studies is that irrespective of scale, the lack of meaningful representation of various knowledge holders in these processes is a significant barrier to recognitional justice and therefore to knowledge integration processes that do not perpetuate othering.

This article may have raised more questions than it has provided answers in its engagement with knowledge integration in ocean sciences and governance. It has partly unpacked the colonial, imperial, and othering underpinning both contexts, but also demonstrates how these pervade moves for integration, given that these instruments are grounded in Eurocentric and western scientific and legal frameworks. These need to be unlearned and decolonised in the first place if any meaningful integration is to take place and to avoid tokenistic subsumption of Indigenous knowledge systems and practices in ocean governance processes.

Conflict of Interests

The authors declare no conflict of interests.

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ARTICLE

Immersion in Discomfort: At the Intersection of Worldviews Toward Co-Governing With Integrity

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Abstract

In the drive to embrace more inclusive, equitable, and respectful approaches to research, academics are increasingly encouraged to engage with diverse and alternate knowledges, including with First Nations and Indigenous Communities. Yet for those working at the intersection of different worldviews—known as the "cultural interface"—the experience can be accompanied by feelings of discomfort. We recognise discomfort as a personal, inner emotion of vulnerability that alerts us to unspoken, difficult conversations; to challenged beliefs and assumptions; and to the limits of our own knowledge. As a group of academics working at the cultural interface, we identify common themes across our collective experiences of discomfort, including fragility and guilt, helplessness, fear, ignorance, shame, challenged conceptions of time, and finally connection and relationality. By openly discussing and confronting our experiences of discomfort, we demonstrate that immersion in discomfort is a journey that provides opportunities for learning, understanding, and fostering co-governing partnerships with integrity.

Keywords

co-governance; cultural interface; discomfort; First Nations; Indigenous; integrity; knowledge; ocean governance; partnerships; worldview

1. Introduction

1.1. Positionality

We write this article from the perspective of settler- and migrant-scholar academics working in Australia. One author is an Egyptian-Australian with ancestral lineage from Kemet (Randa Sacedon [RS]), four authors are Anglo- and/or Irish-Australian (Michelle Voyer, Freya Croft, Elle McNeill, and Anna Farmery), one author is German (Tillmann Boehme), and one author is an Indigenous Maasai woman and scholar from the Kaputei Plains of Kenya (Makrita Solitei). We also invited the perspective of our Indigenous First Nations colleague who is a Yuin/Dharawal custodian, and academic (Jodi Edwards [JE]) to provide a response to our findings.

Whilst the authorship group comprises both Indigenous and non-Indigenous members, the article is primarily focused on the perspectives of researchers who are not Indigenous to Australia. Recognising the need for equitable responses in this space, we maintain that it is neither appropriate nor just to rely on First Nations Australians to guide non-Indigenous Australians through the process of navigating discomfort (Hird et al., 2023). As settler- and migrant-scholars from diverse multicultural and multilingual backgrounds, we draw on our collective lived experiences while critically reflecting on our positionality within a shared settler-colonial context (Section 2). Embracing the responsibility of self-reflection, we actively engage in the "workload" of supporting Indigenous ways of knowing by confronting our discomfort (Hird et al., 2023). This process is vital not only to our research but also to advancing reconciliation across the broader Australian community (Habibis & Taylor, 2015).

References to "our," "us," and "we" in this article refer to the authorship team.

1.2. Article Overview

This article addresses the discomfort experienced by the authors when working with First Nations and Indigenous Communities and knowledges. We identify the location of this discomfort at the intersection of different worldviews, known as the "cultural interface" (Nakata, 2007).

The "cultural interface" as defined by Nakata is the concept of a contested space where two or more knowledge systems, Indigenous and Western intersect, creating a complex interplay of histories, politics, economics, discourses, social practices, and knowledge technologies that shape perspectives on the world (Nakata, 2007). When academics, Indigenous people, and local communities seek out partnerships, the "cultural interface" is often where the partnership begins, and where it can breakdown due to the diverse perspectives and knowledges shared within the space. The scope of this article addresses discomfort at the cultural interface of ocean governance research, as experienced by the authors located on the South Coast of New South Wales, Australia. It does not presume to apply universally to all situations of discomfort.

In recent decades, fisheries and ocean management policy research has been and continues to be carried out with local coastal communities and with First Nations and Indigenous Communities (Cisneros-Montemayor et al., 2016, 2020; Donda & Manyungwa-Pasani, 2018; Espinoza-Tenorio et al., 2013; Nalau et al., 2018; Vierros et al., 2020). Such collaborations are encouraged by the growing global recognition of the historical and ongoing processes of colonisation that lead to damage and marginalisation

of people, culture, environments, and relationships (Ford et al., 2020). Concurrently, there is an increasing appreciation of the value of knowledge and relationships—epistemologies and ontologies—held by First Nations peoples in ocean governance (Austin et al., 2018; Bundy & Davis, 2013; Gilbert, 2019; Hornidge et al., 2023; Salomon et al., 2023; Taylor & Parsons, 2021; Waldmüller et al., 2022; Zurba & Papadopoulos, 2023). These initiatives point to the potential for co-design, co-governance, and multiple ways of learning (Akins & Bissonnette, 2020; Ban et al., 2019; Butler et al., 2022; Chow, 2022; Country et al., 2022; Reid et al., 2020). However, this type of work is laden with inherent challenges. For example, from the outset, there is a tendency for researchers to avoid working in the space, there are ethical questions that are difficult to anticipate, and there is the frustrating prospect of projects being discontinued due to these challenges (Gilbert, 2019; Peters et al., 2018). Additionally, experiences of fragility are known to hinder conversations and research (DiAngelo, 2018). What is less often discussed is how these challenges are addressed in practice (Hird et al., 2023; Niner et al., 2024). This research explicitly engages with those challenges, recognising that whilst this may be taken as examples of "white fragility" it is important to open conversations about the practicalities of working in this space to build knowledge, understanding, and resilience to persevere. By immersing ourselves in discomfort through discussing and exploring the instances in which it arises, and by acknowledging it as a valid emotion, we aim to understand what discomfort means in the context of ocean co-governance partnerships. This objective is distilled into two research questions:

RQ1: What role does immersion in discomfort play in fostering critical reflection and understanding between diverse cultural perspectives?

RQ2: What practical approaches can be drawn from immersion in discomfort to assist researchers and practitioners working at the cultural interface?

As the lead author, I propose that discomfort signals an internal (personal) conflict when assumptions and beliefs are challenged, prompting critical reflection. This discomfort serves as an invitation to actively confront the inconsistencies within our assumptions and beliefs, fostering a deeper alignment with integrity. Recognising, as Boler (1999) suggests, that there is something to learn from our discomfort, we actively acknowledge and address the history of the settler-colonial, migrant, and multicultural society in which we are privileged—a critical first step in the inquiry into historicised ethics (Boler, 1999).

Building on this, Niner et al. (2024) underscore the need to address histories and embrace discomfort as a means of confronting power asymmetries within the academy in ocean biodiversity governance research. They argue that this process disrupts entrenched knowledge hierarchies that cast subjective, cultural, traditional, and Indigenous knowledges as inferior to "Western...rational and objective" knowledge systems (Niner et al., 2024, pp. 2, 15). Such reflection aligns with the broader call to critically examine the origins and impacts of these hierarchies within research, particularly the assumptions and beliefs upon which they rest.

This historical excursion allows us to navigate the "cultural and emotional terrains" that are occupied "less by choice and more by hegemony" (Boler & Zembylas, 2002, p. 108). Hegemony, in this context, refers to the mainstream, "everyday," "common sense," social practices, norms, and structures that are reinforced by entities such as governments, schools, media, and politics (Boler & Zembylas, 2002, p. 108)—where norms and structures are deeply tied to the very assumptions and beliefs that discomfort compels us to interrogate.

This article is structured as follows: Section 2 (context) outlines the shared research setting within the "cultural interface" of the authorship group. It provides an overview of historical policies and legislation that have led to hegemonic political and cultural divisions between First Nations peoples of Australia, settler-colonial Australia, and multicultural Australia; Section 3 (methods) describes three key strategies employed to immerse ourselves in discomfort. First, creating space for uncomfortable conversations. Second, explicitly engaging with subjectivity to conceptualise discomfort, and finally applying broad thematic analysis and critical reflexivity; Sections 4 (findings), Section 5 (discussion), and Section 6 (conclusion) outline the results of this process and its implications; Definitions of various terminology adopted herein is provided in the glossary (Supplementary File).

2. Context

2.1. Our Research

All project team members who participated (participants) in the reflections which underpin this article are listed as co-authors. All are involved in collaborative research projects that work at the cultural interface between Indigenous and non-Indigenous Australians, to various extents. The relevant projects included grass roots collaborations aimed at supporting Aboriginal fishing and aquaculture businesses and sea country management planning. Two broader research projects funded by the Australian Research Council aim to explore how First Nation knowledges might inform broader ocean governance and food systems respectively. These projects are being undertaken in accordance with their associated ethics requirements. These ethical protocols were observed in the development of this article. Critically, many members of the team have undertaken repeated and ongoing cultural immersion, including formal and informal training and mentoring from Indigenous colleagues within our institution, through the Jindaola program (Kennedy et al., 2019) and associated activities. The reflections underpinning this article are therefore based on both practical experience in collaborative research as well as regular involvement in relevant training programs.

We recognise that multiple arenas in ocean governance are marked by power imbalances across the colonial divide, for example, regional and global ocean governance (Adewumi, 2021; Haas et al., 2023), deep seabed mining (Arato et al., 2024), data and global goals (Fisher & Fukuda-Parr, 2019), and research paradigms (Held, 2021). Although there is no explicit power imbalance within our co-authorship group, we acknowledge that the settler-colonial political landscape in which we are situated is inherently characterised by power disparities. This broader context influences our daily lives and, ultimately, our research. The following section unpacks this context further.

2.2. The Cultural Interface of First Nations, Settler-Colonial, and Multicultural Australia

This section provides an overview of Australian national events, legislation, and policies that influence decision-making regarding First Nations peoples, settler-colonial Australians, and multicultural Australians (Table 1). The events, legislation, and policies in Table 1 function as narrative elements, shaping broader societal understandings of cultural and hegemonic social practices, norms and attitudes toward First Nations people, as well as the status of settlers, migrants, and multicultural Australia. The history (and references) presented in Table 1 are neither exclusive nor exhaustive. Notably, a significant gap exists in the Table regarding the thousands of years of First Nations history prior to European exploration of what is now

known as Australia. For further details on historical events refer to the references in Table 1 (see Bodkin-Andrews & Carlson, 2016; Elias et al., 2021; Fozdar & Spittles, 2009; Goodall, 2008; Moses, 2005; Veracini, 2006).

In addition to Table 1, a summary of events of the past 125 years is provided to highlight the parallel development of privileging "white" Australia and creating opportunities for multicultural Australia, in sharp contrast to the historical trauma experienced by First Nations peoples.

Table 1. Historical events and policies influencing Australian social and political attitudes toward First Nations, settler-colonial, migrant, and multicultural communities.

48,000–63,000 BC
Ancestors of First Nations began arriving from south-east Asia 50,000–65,000 BC (Clarkson et al., 2017; Malaspinas et al., 2016)
1600s
Exploration by the Dutch to Australia previously named "New Holland" and Tasmania previously named "Van Dieman's Land" (Martins, 2022)
Early 1700s
Exploration by the British and French (Konishi & Nugent, 2013)
1770s
Captain James Cook expedition to *terra australis incognita* (in English: unknown southern land). Illegitimately claimed *terra nullius* (in English: nobody's land; National Library of Australia, 2024; The National Archives, n.d.)
1788
26 January, Captain Arthur Phillip established the first British colony at the recently named Sydney Cove, proclaiming British Sovereignty (Burdett Smith, 1888)
1788–1934
Frontier wars, massacres, and death by diseases (Clements, 2014; Connor, 2002)
Early 1800s
British navigator Matthew Flinders circumnavigates the continent and proposes the name "Australia" (Flinders, 1803)
1838 Jubilee / 1888 Centenary of arrival of first colony in Sydney Cove
26 January becomes a holiday for settlers (ANTAR, 2024; Burdett Smith, 1888)
1850s
Goldrush migration waves (AMES Australia, 2020)
1901
Federation: 1 January (Parliamentary Education Office, 2024.)
Immigration Restriction Act, Commonwealth 1901
"White Australia" Policy (Brawley, 1995; Jakubowicz, 2012; Martin, 2023)
1909
Aborigines Protection Act, New South Wales 1909
1915
Aborigines Protection Act, New South Wales 1909: Amended to enable thousands of First Nations children to be forcibly taken from their families on the basis of race (Section 13A).

Table 1. (Cont.) Historical events and policies influencing Australian social and political attitudes toward First Nations, settler-colonial, migrant, and multicultural communities.

1920's	
Forced removal of First Nations children from their families (Australian Institute of Aboriginal and Torres Strait Islander Studies, 2022; Human Rights and Equal Opportunity Commission, 1997)	
1930s	
Forced removal of First Nations children from their families (Australian Institute of Aboriginal and Torres Strait Islander Studies, 2022; Human Rights and Equal Opportunity Commission, 1997)	
1938	
26 January becomes known as the "Day of Mourning" for First Nations and subsequently "Invasion Day" and "Survival Day" (Australian Institute of Aboriginal and Torres Strait Islander Studies, 2023)	
1940s	
Forced removal of First Nations children from their families (Australian Institute of Aboriginal and Torres Strait Islander Studies, 2022; Human Rights and Equal Opportunity Commission, 1997)	
Migration waves begin post World War II (Australian National Maritime Museum, n.d.)	
1950s	
Forced removal of First Nations children from their families (Australian Institute of Aboriginal and Torres Strait Islander Studies, 2022; Human Rights and Equal Opportunity Commission, 1997)	
1960s	
Forced removal of First Nations children from their families (Australian Institute of Aboriginal and Torres Strait Islander Studies, 2022; Human Rights and Equal Opportunity Commission, 1997)	
Commonwealth Electoral Act, Commonwealth 1962	
1966: White Australia Policy abolished (Australia's Defining Moments Digital Classroom, n.d.)	
1967: Referendum amended the Australian Constitution to count the "Aboriginal race" in the population count and enable the Commonwealth parliament to make "special laws" for Aboriginals (Commonwealth of Australia, 1967)	
1969: Aborigines Protection Act, New South Wales (1909) repealed	
1970s	
Forced removal of First Nations children from their families (Australian Institute of Aboriginal and Torres Strait Islander Studies, 2022; Human Rights and Equal Opportunity Commission, 1997)	
Multiculturalism policies introduced.	
National Aborigines and Islanders Day Observance Committee (NAIDOC) week observed	
Racial Discrimination Act 1975—Non-whites permitted to vote	
1970s–1990s	
Waves of asylum seekers, immigrants, and refugees known as "boat people," from South East Asia (AMES Australia, 2020; Australian National Maritime Museum, n.d.)	
1980s	
1988: Bicentennial of colonisation	
Local Aboriginal land councils were established followed by the Aboriginal Land Rights Act, New South Wales, 1983; (New South Wales Aboriginal Land Council, n.d.)	
1990s	
Mabo v. Qld (1992) High Court of Australia rejects *terra nullius* recognizing Indigenous land rights	
"Bringing them Home Report"/Stolen Generations Report (1997; (Human Rights and Equal Opportunity Commission, 1997)	

Table 1. (Cont.) Historical events and policies influencing Australian social and political attitudes toward First Nations, settler-colonial, migrant, and multicultural communities.

2000s–2010s
MV Tampa 2001
Formal expansion of Australia's offshore processing facilities for asylum seekers (Doherty, 2021)
National Apology 2007 Rudd (Human Rights and Equal Opportunity Commission, 1997; Reconciliation Australia, 2018, 2020)
Closing the gap policy introduced in 2008 under the Rudd Government (Bond & Singh, 2020; Coalition of Aboriginal and Torres Strait Islander Peak Organisations & Commonwealth of Australia, 2020)
2020s
2021: Census highlights increased cultural diversity (Australian Bureau of Statistics, 2022)
2023: Indigenous Voice to Parliament referendum results in a "no" vote (Australian Electoral Commission, 2023; Biddle & McAllister, 2024)
Shift to trauma-informed truth-telling practices (Bennett & Gates, 2024)

Note: Grey shaded text indicates event(s) occurred over multiple decades

Table 1 details the historical evolution of Australia's racial policies and national identity since the Federation in 1901. It highlights the early establishment of exclusionary measures like the White Australia Policy and the Aborigines Protection Act, which underpinned systemic racism, cultural erasure, and the Stolen Generations (Brawley, 1995; Jakubowicz, 2012; Martin, 2023).

From the mid-20th century, shifts occurred, such as the dismantling of the White Australia Policy, the 1967 Referendum granting greater legal recognition to Aboriginal and Torres Strait Islander peoples, and the introduction of multiculturalism (Australian National Maritime Museum, n.d.; Commonwealth of Australia, 1967; Human Rights and Equal Opportunity Commission, 1997). These changes were juxtaposed with ongoing resistance to social inclusion and persistent inequalities for First Nations peoples. Significant milestones for Indigenous rights included NAIDOC Week, land rights activism, and the 1992 Mabo decision repudiating *terra nullius* (Australian Institute of Aboriginal and Torres Strait Islander Studies, 2023; Australia Law Reform Commission, 1977; Commonwealth Electoral Act, 1962; *Mabo v. Queensland*, 1992; NAIDOC, n.d.)

Efforts toward reconciliation, such as the 2008 Apology and the "Closing the Gap" policies (Coalition of Aboriginal and Torres Strait Islander Peak Organisations & Commonwealth of Australia, 2020; Human Rights and Equal Opportunity Commission, 1997; Reconciliation Australia, 2018, 2020), sought to address disparities but faced criticism for perpetuating systemic inequities (Bond & Singh, 2020; Dudgeon & Walker, 2022; Kendi, 2016; Sims, 2014). According to the most recent 2019 Closing the Gap report, just two of the "Closing the Gap" targets are on track 12 years after they were first set (Amnesty International, 2020).

Annual events like NAIDOC and National Reconciliation Week commemorate progress and highlight ongoing challenges (Human Rights and Equal Opportunity Commission, 1997; Reconciliation Australia, n.d., 2018). However, the 2023 referendum rejecting the Indigenous Voice to Parliament revealed enduring societal divides and resistance to fully addressing historical injustices (Australian Electoral Commission, 2023; Biddle & McAllister, 2024).

In the present day, Australia is a multicultural society (Australian Bureau of Statistics, 2022) that grapples with the legacies of its colonial past, racial hierarchies, and the tension between diverse cultural identities and the unresolved traumas of First Nations peoples.

This historical background is a critical context underpinning the experience of discomfort and the emotional journey experienced by the authors. As Maddison (2012) explains, Australia's setter-colonial history of violence and dispossession has left a deep, psychological legacy that hinders reconciliation.

The narrative of Australian post-colonial history is deeply politicised, influencing national identity and collective memory (B. R. O. Anderson, 1991; Shin, 2011). The dominant narrative of the past is shaped by the emphasis on certain aspects while others are overlooked or forgotten. Confronting a previously unacknowledged version of history can cause discomfort experienced as "collective shame and pain" (McKernan, 2016, p. 2).

2.3. The Role and Importance of Discomfort

Emotions, like history, are politicised as they reflect broader societal contexts (Ahmed, 2014; Bondi, 2005, p. 436). Whilst occurring on a personal bodily scale (K. Anderson & Smith, 2002; Davidson & Milligan, 2004) emotions can also extend beyond the individual by permeating physical and social environments, as they arise from and reflect broader societal contexts. Emotions, therefore, are deeply tied to the identity of place (Massey, 2011) and can be collectively experienced on a national scale. Ahmed (2014) argues that emotions shape societal "truths" and drive "othering," categorising those outside mainstream norms and evoking fear, anger, shame, and disgust, which can fuel racism, homophobia, and sexism.

By examining key historical moments, and the politicised nature of emotions, national identity, and collective memory, we emphasise that we (and our research) are shaped by context. Neither societies nor individuals and their emotions exist in isolation; past experiences are intricately connected to national history and collective memory, as well as the extent to which self-identity is intertwined with these elements. Thus, understanding the historical context from which this research emerges is critical in understanding the discomfort that arises in co-governance settings.

Advancing from here, the pedagogy of discomfort teaches us to go beyond mere spectating of our histories to the "collective witnessing" of ourselves within them (Mills & Creedy, 2021; Niner et al., 2024). It delves into the most challenging vicissitudes of human fears, requiring us to face an "ambiguous self" with courage and flexibility (Boler, 1999, p. 199). Courage is needed to confront the "ontological supremacist" who manifests fear, shame, and anger when ways of knowing and assumptions are challenged (Hird et al., 2023, p. 3).

This curious trepidation is accepted because discomfort frequently arises when multiple perspectives and knowledges are brought together in co-governance contexts. Thus, we must consider the role discomfort plays in fostering critical reflexivity, enabling us to better understand other cultures and adopt practical approaches from this immersion, ultimately moving toward co-governing with integrity. Guided by Boler's (1999, p, 199) assurance that "through education we invite one another to risk living at the edge of our skin," we can find the courage to embrace discomfort as it offers "the greatest hope of revisioning ourselves."

The following section describes how we made space for uncomfortable conversations and how we sat with our ontological privilege (techniques suggested by Hird et al., 2023).

3. Methods

3.1. Making Space for Uncomfortable Conversations

The data referenced in this research includes the collective research experiences of the authors and their broader individual life experiences. The process of drawing down data from this range of experiences was filtered through an interview process designed to facilitate the sharing of personal experiences of discomfort encountered during our shared research projects.

All co-authors (except JE) participated in one-on-one, half-hour recorded interview sessions with the lead author. These sessions were conducted over private, face-to-face Zoom calls, creating a comfortable space for discussing discomfort (Applebaum, 2017). Each recording was shared with the respective co-author but not with the rest of the authorship group. At the start of each interview, the questions were displayed using Zoom's "Share Screen" function. Participants were not required to answer all the questions (except for Question 7) or to address them specifically, directly, or in order; rather, the questions served as conversational prompts (Box 1).

Box 1. Interview prompt questions.

> Please be aware of any potential to appropriate and please acknowledge where appropriate.
> 1. Have you met Indigenous knowledge holders?
> 2. When have you experienced discomfort?
> 3. What did it feel like?
> 4. What was being challenged?
> 5. Do you think about the thing that was being challenged differently? If yes, in what way?
> 6. What if anything did you do about the feelings of discomfort?
> 7. What would you recommend to other researchers?
>
> Anything you would like to add? An anecdote to share?

3.2. Explicit Engagement With Subjectivity to Conceptualise Discomfort

The interviews were reviewed by RS within a 12-month period, and reflexive thematic analysis was conducted by RS to identify themes of discomfort (Braun & Clarke, 2013; The University of Auckland, n.d.-a; Section 3.3). It is acknowledged that the identification of these themes was influenced by RS's subjectivity, including RS's personal experiences of discomfort and understanding of each participant's exposure to discomfort. Therefore, RS's subjectivity is considered a valuable resource for both interpreting and reconstructing the interview data (Braun & Clarke, 2013; The University of Auckland, n.d.-a). RS's subjective reflections in interpreting and presenting the interview data are included in Box 2.

Box 2. Subjective reflection.

- My position is both as a migrant-settler as well as an Australian scholar who has grown up in Australia. My responses to each participant's comments are included in Table 2, labelled "RS response." These responses are primarily made in hindsight, though some were offered during the interviews themselves.
- The interview data is divided into two groups: A and B. Group A consists of participants whom I perceived had more interactions with First Nations and Indigenous Communities and more opportunities for reflection. Group B includes participants I perceived to have had fewer interactions.
- I perceive myself positioned across Groups A and B, acting as an intuitive observer and empathetic researcher who draws upon my personal experiences of discomfort. The challenge of quantifying the emotions underlying discomfort was not one I could address empirically, so I relied on intuition to guide my findings, conceptualising discomfort as a journey. Additionally, empathy plays a crucial role in understanding how others experience discomfort, which is essential for its conceptualisation. Maintaining empathy requires moving beyond strict adherence to objective neutrality. In this type of research, it is often more desirable and legitimate to have a researcher who can relate to participants and shares "common wounds" (Gair, 2012, p. 138).
- The conceptualisation of discomfort as a journey emerged from the sense that the emotions experienced by Group B were similar to those already experienced by Group A. Group A participants also often expressed having moved beyond fear-driven experiences, such as fragility, and into relationality. Some participants also explicitly described being on a journey. To visualise this, I created a basic conceptual model, which I presented to the participants (Figure 1). Validation of this intuitive finding came when participants confirmed the conceptualisation of discomfort as a journey.
- I also engaged in a separate discussion with our First Nations colleague JE (Box 3). Edwards' agreement with the journey conceptualisation further validated this intuitive finding.
- Subsequent discussions with co-authors focused on the juxtaposition of the emotions underlying discomfort: how they are experienced simultaneously, how the journey is not linear but rather marked by emotional spikes and spirals, and how the order of emotions does not necessarily follow the sequence depicted. In response, a spiral model was developed to capture the dynamic nature of this emotional journey (Figure 2).

3.3. Broad Thematic Analysis and Critical Reflexivity

The themes from the interview data were derived using a critical-realist perspective aligned with Braun and Clarke's (2013) experiential inductive thematic analysis, which emphasises understanding the purpose of analysis before determining the methodology (see The University of Auckland, n.d.-a). The flexibility of reflexive thematic analysis supports this approach (The University of Auckland, n.d.-a, n.d.-b) and is complemented by subjective engagement (Section 3.2). Quotes from the interviews that offered expressions and/or impressions of personal significance that triggered discomfort were selected to identify themes (Braun & Clarke, 2013; The University of Auckland, n.d.-b).

Interviews were interpreted using critical reflexivity through a "threefold" analytical framework described by Gonda et al. (2021), which acknowledges the role of affect and emotions as a way of learning that can help shift attention from the individual to collective responsibility. According to Gonda et al. (2021), this shift can be achieved by: (a) creating a sense of interconnectedness and emancipation through a shared vulnerability, (b) dealing with uncertainty and (c) challenging hegemonic knowledge politics. An iterative process of reflecting and writing up findings and discussion was led by RS with co-authors. As a further step, we sought

the perspective of our First Nations colleague, JE (Box 3) to offer insights and a response to the discomfort journey (Figure 1). This step aimed to incorporate a First Nations perspective and enrich our understanding of the responses and findings.

4. Findings

The findings are presented as follows:

Section 4.1. Presents the interview data, detailing participant sentiment and thematic analysis (Table 2).

Section 4.2. Provides critical reflexivity and broad thematic analysis of the interview data (Table 3).

Section 4.3. Describes the conceptualisation of the discomfort journey arising from the interview data (Figure 1).

Section 4.4. Presents JE's response to the findings (Box 3).

Section 4.5. Incorporates the importance of time and reflection in the processing of discomfort (Figure 2).

4.1. Presentation of Interview Data Detailing Participant Sentiment and Thematic Analysis

Table 2 captures the dominant sentiments observed by RS of each participant. The participants were not interviewed in the order presented. As noted in Box 2, the findings are presented in two groups: those perceived to have more exposure to discomfort at the "cultural interface" (Group A) and a second group perceived to have less (Group B). Themes and supporting quotes are shown in Table 2, along with participants' recommendations for other researchers who may also be confronting discomfort. Additionally, the interviewer/lead author responses to participants' reflections are also documented.

Table 2. Participant sentiment and thematic analysis.

Group A		
Participant 1: helplessness, journey, and fear		Theme
1.1. Supporting quotes	**a.** "[I felt] helplessness because I was not in a position to help so [I] had to stand aside and that is not characteristic of me"	Helplessness
	b. "It felt like hard marsh swamp land—mushy ground, mosquitoes, hard to walk forward, water weighing it down, bad smell, flies. Every move was hurt and met with hurt"	Helplessness
	c. "There is no sounding board, who do you talk to? Where do you go? It is also a question of leadership and how to deal...we were made [to] carry on as normal"	Relational-governance
	d. "Feeling of fear to step inside cultural space and then back out again"	Fear
	e. "The journey is just being re-directed and not ending"	Journey
	f. "Who am I being integral to?"	Integrity

Table 2. (Cont.) Participant sentiment and thematic analysis.

Group A		
Participant 1: helplessness, journey, and fear		**Theme**
1.2. Recommendations	**a.** "If there were more academics in this space we could help each other out of the marsh and tag team and then it would be easier to navigate rather than be hushed and also have leadership from someone who understands it is a hard place to be but it is a space of learning but then elasticity to navigate it"	Support network Relational-governance
	b. "There should [be] space to say 'I feel angry, I feel sad, I feel defeated.' When we say 'I feel' we can then have direction to where we need to go because the logical approach becomes unrealistic because it does not come near the issues that the feelings go to the heart of"	Vulnerability
	c. "In governance there is no space to STOP and question what is happening to address the discomfort, the hurt, the pain. There is just a new policy and just move on without touching what is happening. But we need to touch it we need to face it"	Relational-governance
1.3. RS response	**a.** Research leads working in co-partnerships, co-design, and toward co-governance require empathy and experience in handling discomfort	Support network
	b. Transparency about emotional dimensions at the cultural interface needs to be acknowledged and engaged. Logical and rational approaches do not reach the core of the issues, whereas emotional engagement can resonate more deeply	Relational-governance
Participant 2: fragility to relationality, time, ignorance, and journey		
2.1. Supporting quotes	**a.** "Discomfort changed over time...common for non-Indigenous researchers is 'white fragility' I'm going to say the wrong thing, I'm going to offend, white guilt. I definitely felt that at first and it evolved"	Fragility Fear Guilt
	b. "[I was] trained to be 'impartial,' distant, objective, don't get personally involved, [and] don't let feelings get involved. A more relational approach challenged that, I was excited about it but also uncomfortable"	Relationality
	c. "The other area of discomfort is the temporal aspect of time as being not linear. I really don't know what to do with it. I love that discomfort. It's challenging in an intellectual sense, uncomfortable in quite different ways"	Time
	d. "It has been learning and unlearning and relearning. And there is still so much that I don't know. I adjust the way I think and act and it took me so long"	Uneducated Ignorance
	e. "We were not given a true history of this country"	Uneducated Ignorance
	f. "I don't feel responsible for what predecessors have done but I do feel responsible for my own ignorance"	Ignorance
	g. "A relational approach needs to involve more-than-human healthy relationships not just with each other but also with our environment. I think that is the fundamental shift we need"	Relationality

Table 2. (Cont.) Participant sentiment and thematic analysis.

Group A		
Participant 2: fragility to relationality, time, ignorance, and journey		
2.2. Recommendations	**a.** "Rather than managing the environment we are in relation to it. Managing sounds very transactional. Take the good and bad and navigate it"	Relational-governance Journey
	b. "To be more engaged with 'trauma-informed research' and we are dealing with trauma in the landscape so perhaps a relational approach requires us to think more compassionately"	Trauma-informed research Relationality
2.3. RS response	**a.** Why can't we engage in more relational governance approaches?	Relational-governance
	b. We need to take on the responsibility of educating ourselves about the First Nations history of this country as the education we received at school was misleading and redacted	Self-education
	c. Avoid being hindered by fearful feelings: continue on the path one step at a time	Journey
Participant 3: connection and relationality, time, and journey		
3.1. Supporting quotes	**a.** "I understood that all things are equal and that you have to go beyond your brain capacity and use your other senses"	Relationality
	b. "How you feel and how to engage the interconnectedness of your heart, gut and head it was a way different way of being in the world and then it was very discomforting spiking in and out of that way of being"	Connectedness
	c. "Some circles are short—the week the month. Some circles are much longer—over thousands of years"	Time
	d. "We don't have a 500-year strategy or 1000 years. We have 3–4 year strategies based on election cycles. And then we lose sight of the causes of the problems and fires we are trying to put out. So we become reactive because the ability to pick up signs early on is becoming lost. Longitudinal data exists in those cultures but in 250 years we managed to f*** it all up"	Time
	e. "By accepting journey and looking back to who I am and where I am going…now I feel very comfortable. A lot of underlying anxieties have gone so I have a level of comfort in myself"	Journey
3.2. Recommendations	**a.** "Being genuine, being yourself, don't go in with a hidden agenda, investing time with people and being okay with however long it takes"	Connection Transparency Give time
	b. "Relationships are built over time, they need time to develop and to build trust"	Relationality Give time

Table 2. (Cont.) Participant sentiment and thematic analysis.

Group A		
Participant 3: connection and relationality, time, and journey		
3.2. Recommendations	c. "Instead of rush rush rush it is about having a yarn, being someone who is willing to listen to their story and willing to invest their time in them. Rather than it being transactional. Are you devoted or is it a tick-box exercise? You can't go halfway. Either you're all in or you're not. If you don't believe in it, don't go there, just don't do it. If you go halfway and then get distracted by another grant and then come back later because there is an opportunity, you won't be able to, you will have closed the door"	Give time Relationality Commitment
	d. "You need to devote time to it and let it sink in. Just busy busy busy does not allow you to go for a walk and even just let the subconscious sort it. Have an anchor at home"	Give time Reflection
3.3. RS response	a. How can we know that tactile and bodily knowledge is valid when we have been brought up to dismiss it? Recognise and find ways to validate tactile, and bodily knowledge and responses. Ask knowledge holders who have not forgotten this part of ourselves	Validate subjectivity
	b. Take time. It is a long journey	Give time Journey
	c. Committment	Committment
	d. As a Western-trained scholar, I find it challenging to discuss connection without also discussing relationality	Connection Relationality
Group B		
Participant 4: naïvety, ignorance, and time		
4.1. Supporting quotes	a. "The main source of discomfort is naïvety and being out of depth and how to handle a situation out of respect and in an appropriate way"	Fragility Ignorance
	b. "I walk in feeling uneducated about how to handle myself appropriately and naïve"	Uneducated Fear
	c. "Growing up in Australia it feels like the way to deal with discomfort is to brush over the surface and avoid it"	Uneducated
	d. "I took time to look at short comings in terms of history, racism, [and] cultural insensitivity"	Uneducated Time
	e. "We haven't been educated in a way that allows open questions and [we] avoid discussing cultural differences"	Fragility
	f. "It's interesting to live overseas and have people recognise that you are Australian and then bring up that you are racist....But it's not me....I had to accept, yes, the culture is racist and then come home and sit in that discomfort"	Fragility
4.2. Recommendations	a. "Pre-reading of context before coming together, to enter the space with more empathy"	Trauma-informed research

Table 2. (Cont.) Participant sentiment and thematic analysis.

Group B		
Participant 4: naïvety, ignorance, and time		
4.2. Recommendations	**b.** "I would go forward with transparency and honesty of gaps of knowledges and understanding of other people's perspectives. I'd love to be able to…walk in and say I don't know…[it] adds humanity and humility to the space"	Transparency Vulnerability
	c. "Acknowledging that it will be uncomfortable"	Vulnerability
4.3. RS response	**a.** Acknowledge ignorance, discomfort, and naïvety as normal experiences in this space	Vulnerability
	b. I also felt uneducated about the First Nations people of Australia even though I went to school in Australia. I felt cheated and misled on the education I received in Australia's history. I was compelled to do something about it when I realised I was not the only one who felt this way	Self-educate Support network
	c. I also did not know any people who identified as Aboriginal growing up	Support network
Participant 5—guilt, fragility and journey		
5.1. Supporting quotes	**a.** "I remember a meeting where the knowledge holder was talking about ongoing trauma and I felt so overwhelmed I wanted to cry in the face of my unrealised complicitness in the whole mess. I didn't want to cry because I'm not the victim—that was one of the most powerful instances of guilt, I didn't know what to say"	Fragility Ignorance Guilt Helplessness
	b. "Realising that my family has helped build 'white Australia' and my family has always had money; and learning that these things continue to happen in the modern day was very confronting"	Fragility Guilt
5.2. Recommendations	**a.** "Early engagement is important because entering with pre-conceived ideas about what should be done, the response can be—hang on you haven't consulted us—and then you have to backtrack and re-think how it could work or might look like in the community"	Relational-governance Trauma-informed research Co-design
	b. "You don't really come out the other side, you just start and keep growing. Think of it as a journey. If you can find a shared and personal path with the Aboriginal community then that is a good outcome"	Journey
5.3. RS response	**a.** Experiences of fragility can be quite acute for persons who have grown up in societies that held a strong legacy and imprint of the "White Australia" policies of the early 1900s	Trauma-informed research
	b. Before initiating co-governance partnerships it is important to engage in cultural education. Additionally, consult partners about project expectations to facilitate authentic co-design	Relational-governance Co-design
Participant 6: shame and ignorance		
6.1. Supporting quotes	**a.** "[I felt] discomfort on a personal level being ignorant not knowing earlier. And then discomfort on a broader lever about the structures that facilitated that, and ongoing racism. And this comes across as shame"	Ignorance Uneducated Shame

Table 2. (Cont.) Participant sentiment and thematic analysis.

Group B		
Participant 6: shame and ignorance		
	b. "[Tutoring] Indigenous students…[I] had to reconcile the fact that I was not Aboriginal….And…keep things respectful…humble, transparent, about who I am, what knowledge I have and what I still have to know"	Transparency
	c. "It is sad and a shame that I did not have engagement with Aboriginal people and knowledge growing up. It was not until university honours even though I studied history as an undergrad"	Shame Ignorance Supported networks
6.2. Recommendations	**a.** "Be okay with making mistakes, be okay with not knowing, be open to changing and being told you are wrong"	Vulnerability
	b. "Put aside the shame and fear of being wrong and ask questions even if they are stupid"	Vulnerability Transparency
6.3. RS response	**c.** Discomfort, shame, and fear are common reactions in this context, and can be acknowledged to facilitate progress	Support network Relational-governance

4.2. Broad Thematic Analysis and Critical Reflexivity of Interview Data

Eight themes (emotions) of discomfort are identified: (1) fragility and guilt, (2) helplessness, (3) fear, (4) ignorance, (5) shame, (6) connection, (7) relationality, and (8) time. Table 3 summarises these eight themes with reference to interview data in Table 2. Whilst each theme warrants individual unpacking, for the purpose of this publication the themes are discussed concisely (and some jointly). Moreover, the emotion of guilt was not standalone, rather it traversed fragility, helplessness, fear, ignorance, and shame and is discussed in the context of those themes (where relevant). Together, these themes represent the "emotional landscape" of discomfort within each of us, capturing the journey one navigates when engaging with discomfort.

Table 3. Broad thematic analysis and critical reflexivity of interview data.

1. Fragility and guilt	Some participants implicitly expressed discomfort when confronting their race and the overwhelming sense of guilt that accompanied it (5.1a and 5.1b)
	Guilt was expressed with respect to not knowing Aboriginal protocol, the true history of Australia, and for the trauma experienced by Australia's First Nations people (2.1a, 4.1a, and 4.1e–f)
2. Helplessness	In certain situations, participants expressed feelings of being ill-equipped and un-supported (1.1a–c and 4.1a–b). Examples of helplessness can occur when confronted with conflict within Indigenous Communities and having the inability (lack of standing) to speak up and participate in its resolve. As one co-author described in interviews, it was like moving through a dense swamp (1.1b). Helplessness also occurs when there is a lack of infrastructure or process in the wider institutional setting to discuss situations of discomfort and conflict (1.1c)
	Some participants also expressed helplessness as not-knowing, particularly, when realising the enormity of colonisation in Australia and their ignorance about it (2.1d and 5.1a)

Table 3. (Cont.) Broad thematic analysis and critical reflexivity of interview data.

3. Fear	The feeling of fear was expressed by participants as a fear of entering cultural spaces (1.1d), of making mistakes, and of saying or doing the wrong thing culturally (2.1a and 4.1a–b)
4. Ignorance	Notably, the participants who grew up in Australia, collectively witnessed ignorance, naïvety, and lack of education regarding First Nations peoples and the concealed truths about their treatment, which remains largely absent from public awareness in the Australian community (2.1d–f, 4.1a–e, 5.1a–b, and 6.1a). This finding was not associated with those participants who did not grow up in Australia
	Ignorance can also be closely related to fragility when one becomes aware (previously ignorant) of one's own culture as racist; a realisation which can be confronting (4.1f)
5. Shame	Ignorance often links to shame, as was expressed by participants when they felt shame not knowing the true history of First Nations peoples of Australia (4.1c, 6.1a, and 6.1c). The experience of shame was expressed as both personal and national (4.1c)
6. Connection	Connection was expressed as an awareness of one's interconnectedness with other sentient beings (3.1a), as well as an awareness of the interconnectedness of one's cognitive and other tactile ways of knowing (3.1a–b)
7. Relationality	Relationality was expressed as a necessity for vulnerability to engage emotionally with core issues, moving beyond neutral objectivity (1.2c and 2.1b). It was also expressed, as a dimension of connection to the more-than-human elements of life (2.1g, 2.2a, and 3.1a), and a desire for empathy and compassion (1.2c and 2.2b)
8. Time	Connection and relationality were interlinked and contextualized within time. Fostering relationality requires connection, which in turn demands an investment of personal time and commitment (3.2b and 3.2c)
	Time is also required for self-education and self-reflection (4.1d and 3.2d)
	Discomfort with time, emerged in attempts to engage with non-linear conceptions of time (2.1c), alongside an unfamiliarity with longitudinal time scales (3.1c and 3.1d)

4.3. Conceptualisation: A Journey of Discomfort

Reflecting on the interview data (including the subjective reflection, see Box 2) it was considered that the eight themes comprise a journey of discomfort. Incorporating cyclical conceptions of time and iterative processes, a circular diagram was generated "mapping" the eight emotions (Figure 1). Contrary to the cyclical appearance of Figure 1, one's journey through discomfort can begin with any of the eight identified emotions and does not necessarily follow the depicted order. Furthermore, the journey is not as smooth as the conceptual diagram suggests, nor does fragility necessarily follow relationality. Discomfort was also described as involving a "spiking" in and out of these emotions underscoring its dynamic and non-linear nature.

The clockwise representation of the emotions suggests a possible pathway starting at fragility, moving clockwise with the hope of arriving at connection and relationality. However, paralleling this suggested movement through discomfort, the emotions may also move in an anti-clockwise direction. For instance, a person may enter a discussion/forum with an open sentiment of relationality and connection but leave with a sense of fragility when their opinions, voice, and knowledge are not validated.
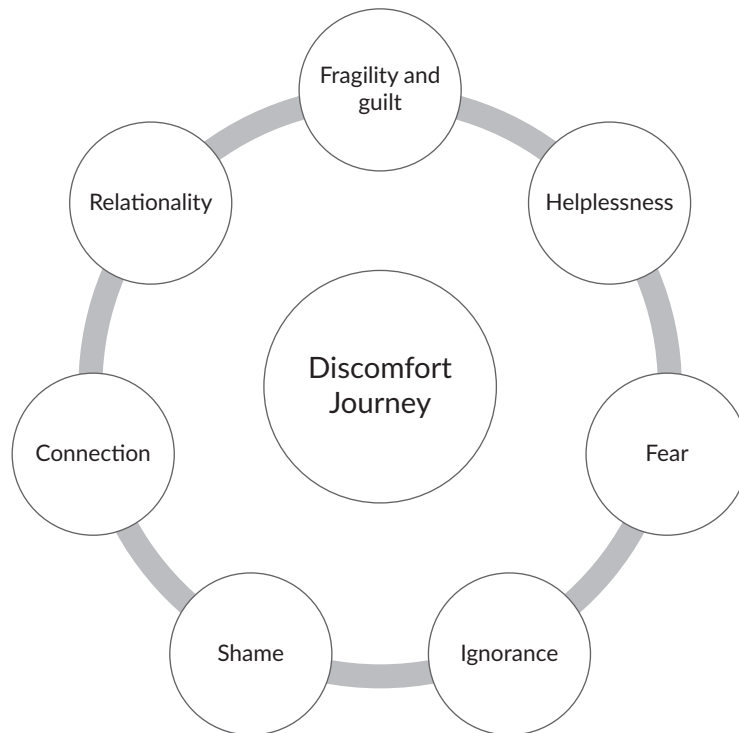
Figure 1. Conceptual journey of discomfort.

4.4. Response to Findings From Indigenous Voice

The conceptual journey of discomfort was presented to JE and her response welcomed. A brief statement on JE's background and the interchange between RS and JE is recalled at Box 3.

Box 3. Response from Indigenous voice JE.

JE's expertise encompasses Aboriginal cultural practices, with a particular emphasis on language and story sharing. In particular, stories that are embedded in Land, Sea, and Sky Country and whale migrations. Her work includes a focus on story sharing and its intersection with science and traditional ecological knowledges, particularly through the enactment of these narratives in interactive public space installations (Informit, 2023; O'Brien, 2023; Shellharbour Civic Centre, n.d.). JE and I engaged in an informal, unrecorded dialogue in which I presented the conceptual journey of discomfort (Figure 1). During our discussion, I elaborated on the participants' experiences of navigating the various emotions associated with discomfort, particularly the notion of "spiking in and out of" these emotions. I sought JE's opinion on this conceptualisation, drawing on her knowledge as an Indigenous scholar to provide critical insights and broaden our interpretive framework. Our discourse is recalled as follows.

JE immediately related to the discomfort journey, stating: "I experience this from the other side." She recounted how, each time as an Aboriginal person, when stepping into a colonised space, discomfort was experienced especially as fragility, fear, and vulnerability, simultaneously. "I feel all of these emotions....I jump between them and feel them all at the same time."

JE is often invited to attend community meetings to represent Aboriginal stakeholders. At meetings, when contemplating whether to speak up or stay silent, she "reads the room" to know whether she will be supported by others present. JE carefully chooses spoken words and when to utter them. JE endures her discomfort whilst it goes unnoticed by the rest of the room. JE interprets and sits with her discomfort to

defend Aboriginal culture and Aboriginal values. In this setting, JE explained that she must figure out how best to protect herself from being accused as an aggressor (should she say anything that triggers "white fragility") whilst still addressing the best interests of the stakeholder she has been called in to represent.

A striking response from JE is that she resonated with the discomfort journey conceptualisation (Figure 1). There was no criticism or suggestion to modify it. JE's response reminds us that discomfort is also experienced "from the other side." When we feel discomfort, an opposite, magnified measure of our discomfort is simultaneously experienced by the Indigenous person(s) in the room. We are not alone in our discomfort.

What is disquieting about these observations is that, when colonised spaces make tokenistic gestures to include Aboriginal stakeholders, they often ignore what is truly at stake: the knowledge and cultural practices of First Nations peoples, especially when these spaces overlook their discomfort.

5. Discussion

5.1. Big Time Journey of Discomfort

A key finding in the interviews is the importance of time, giving time, taking time, and time to reflect (Theme 8–Time, Table 3). Each emotion on the discomfort journey warrants processing as it arises, they are not trivial sentiments. The colloquial phrase "big time" is commonly used as an intensifier across various cultures, including among Australia's First Nations people. Adopting its usage here, it denotes the intense emotions associated with discomfort, as well as the significant commitment in personal time and personal growth on the discomfort journey. Its usage across cultures also enhances its relevance in this context.

Upon reflecting on the findings with the authorship group, it was proposed that a spiral more accurately represents the trajectory of the discomfort journey. Figure 2 incorporates the time and reflection required to process each of the strong emotions (into a spiral), emphasising the need for flexibility in agendas and time
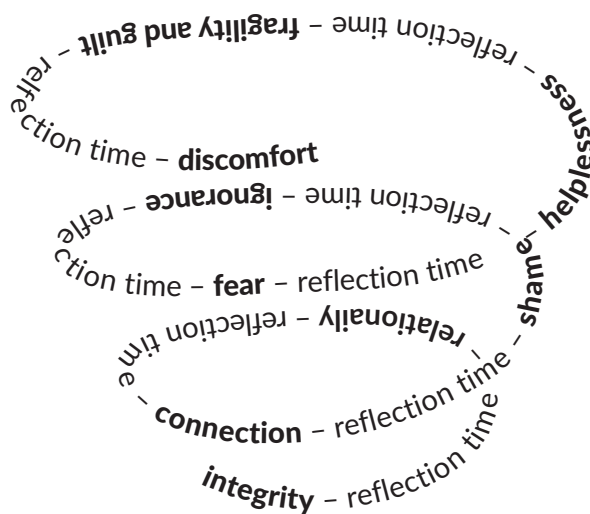
Figure 2. Big time journey of discomfort.

frames. The spiral representation illustrates how emotions coexist, moving from the outermost layers of discomfort toward integrity. Additionally, the aspect of a three-dimensional spiral further highlights the dynamic process of vertical spiralling—up and down—as well as the "roller coaster" spiking in and out of emotions that we navigate until we reach an inner core of integrity.

5.2. Recommendations

For researchers engaged in ocean governance partnerships involving multiple cultures and worldviews, participants proposed the following recommendations to address discomfort and engage effectively.

- Foster support networks: Researchers, particularly research leads, should approach discomfort with compassion and empathy, such as building support networks to understand Indigenous and First Nations cultures and histories. This can be done through initiatives such as cultural immersion programs, collective historical witnessing, and establishing meaningful relationships with Indigenous and First Nations communities (Table 2: 1.2a, 1.3a, 4.3b–c, 6.1c, and 6.3a).
- Create space for uncomfortable conversations: Establish judgement-free environments where participants can openly discuss emotions, concerns, fears, and discomfort, particularly in the context of co-design and co-partnership initiatives (Table 2: 1.2b, 4.2b–c, 4.3a, 6.2a–b, and 6.3a).
- Implement relational-governance models: Move beyond strictly rational and logical frameworks by incorporating and validating emotional responses and relational values as integral to governance practices (Table 2: 1.2c, 1.3b, 2.2b, 2.3a, 5.2a, 6.2b, and 6.3a).
- Adopt trauma-informed research practices: Ensure researchers are informed about the trauma experienced by Indigenous and First Nations communities, as well as their own communities, and employ empathetic strategies to engage with others while prioritising self-care in this context (Table 2: 2.2b, 4.2a, 5.2a, and 5.3a).
- Promote self-education: Encourage researchers to actively learn about the histories, contexts, and cultures of the Indigenous and First Nations communities they collaborate with to cultivate informed, respectful, and empathetic engagement (Table 2: 2.3b, 4.2b, and 4.3b).
- Recognise the discomfort journey: Acknowledge that feelings of discomfort are natural in this work. Confronting and embracing discomfort is a critical first step in fostering connection and relationality within partnerships (Table 2: 1.1e, 2.2a, 2.3c, 3.1e, 3.3b, and 5.2b).
- Transparency: Be transparent about personal gaps in knowledge, areas of expertise, and intentions. Openly acknowledging ignorance and limitations builds trust and authenticity (Table 2: 3.2a, 4.2b, and 6.2b).
- Commit time and recognise alternative temporal frameworks: Dedicate time to self-reflection, relationship-building, and long-term engagement. Researchers unwilling to invest such time should reconsider their participation in this work (Table 2: 3.2b–d, 3.3b–c, and 4.1d). Additionally, researchers should embrace diverse temporal frameworks and longitudinal time, recognising time not solely as linear but as encompassing seasonal rhythms, migration patterns, and co-existence (Table 2: 2.1a, 2.1c, and 3.1c–d). Appreciating time in this broader sense reinforces the relational approach, fostering trust and mutual understanding in collaborative efforts.
- Validate subjective ways of knowing: Recognise that human understanding extends beyond cognitive abilities. By embracing holistic ways of knowing and connecting with one's entire self, researchers may foster a sense of interconnectedness within themselves, the environment, and others, leading to more wholistic outcomes (Table 2: 1.2b–c, 1.3b, 3.1a, and 3.3a).

5.3. Further Research

A further consideration of this study would be to include more explicit interview questions addressing sentiments related to integrity. While integrity remains a concern, the focus of this article primarily reflected experiences of discomfort at the cultural interface and the negotiation of that space.

Communication of the complexity of the discomfort journey could be enhanced through qualitative and artistic techniques, like qualitative mapping (Brennan-Horley & Gibson, 2009) and emotional mapping via artistic expression (Caquard & Griffin, 2018; Qutub, 2012).

6. Conclusion

In this article, we proposed that immersion in discomfort is a learning journey headed toward co-governance partnerships with integrity. We encouraged researchers, starting with ourselves, to engage with discomfort to better understand the challenges at the cultural interface. We started by asking, "What role does immersion in discomfort play in fostering critical reflection and understanding between diverse cultural perspectives?" (RQ1).

First, we made time and space for uncomfortable conversations and reflecting on our discomfort (immersion). Our findings then led us to answer RQ1 with, "The big-time journey of discomfort" (Figure 2). Recognition of intense emotions of discomfort as embedded within a journey enables us to continue moving through them rather than remaining static or hindered by them. Continuing to navigate discomfort opens opportunities for reflection, learning, reckoning with historical wrongs, and challenging hegemonic knowledge and politics. These important processes are crucial to fostering authentic and committed co-governance partnerships with First Nations and Indigenous Communities—and in the Australian context to advancing reconciliation across the broader community. Another important finding was the need to allocate sufficient time to support these processes effectively.

Our second research question asked, "What practical approaches can be drawn from immersion in discomfort to assist researchers and practitioners working at the cultural interface?" (RQ2).

As each participant shared their recommendations, we identified nine practical insights for navigating the cultural interface (see Table 2 and Section 5.2): fostering support networks; cultivating spaces for uncomfortable yet necessary conversations; implementing relational-governance models; adopting trauma-informed research practices; promoting self-education; recognising the discomfort journey and its transformative potential; ensuring transparency; committing time and acknowledging temporal frameworks; and validating subjective epistemologies.

By fostering engagement with these recommendations and practices, we envision pathways for addressing structural inequities and nurturing meaningful partnerships that honour both cultural integrity and relationality. Integrity arises not from avoiding discomfort but from embracing it as part of a transformative journey. True commitment to co-governance and relationality demands an ongoing willingness to reconcile internal discomfort and to dedicate time to the reflective, inner work required of us. This iterative process not only fosters personal growth but also strengthens our capacity to engage authentically and ethically in complex, relational spaces.

Recognise discomfort. It is a feeling. It is the seat of learning. You are in the right place.

Conflict of Interests
The authors declare no conflict of interests.

Supplementary Material
Supplementary material for this article is available online in the format provided by the author (unedited).

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Impact Through Transdisciplinary Centres: Reflecting on Ocean-Related Centres at Two Universities in Northern Europe

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Abstract

A healthy ocean is crucial for a sustainable future. Universities play a key role in supporting societies to understand marine ecosystems, humanity's impact on them, and how to uncover sustainable solutions. This practice-based article examines how universities can enhance their societal impact by developing new organizational models that integrate research, education, and collaboration with societal stakeholders. It poses critical questions: What incentives drive researchers to make an impact or make their results usable? How can universities promote pathways to societal impact? And how do new organizational forms, such as transdisciplinary centres, influence traditional university structures? The article compares two transdisciplinary centres, the Centre for Sea and Society at the University of Gothenburg, Sweden, and the Center for Ocean and Society at Kiel University, Germany. Both centres aim to address urgent ocean-related challenges by fostering collaboration across disciplines and engaging external stakeholders. Gothenburg's centre works across seven faculties, promoting a broad range of activities, while Kiel's centre has a more focused agenda on marine resource management, geohazards, and food security, supported partly by government funding through the university. Key findings reveal that while these centres play a vital role in building networks and addressing global sustainability challenges, they face challenges in securing funding, integrating into traditional university structures, and measuring societal impact. Kiel's core funding allows a long-term strategy, but most work still depends on project funding whereas Gothenburg's reliance on university resources requires regular justification of its relevance. Balancing academic missions with societal impact remains a central trade-off, but these centres demonstrate how universities can advance transdisciplinary research and contribute to a sustainable future.

Keywords

future university models; marine research; ocean solutions; transdisciplinary centres; university impact

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1. Introduction

In this practice-based article, we examine how researchers at the University of Gothenburg in Sweden and Kiel University in Germany are actively developing new frameworks for societal interaction and impact. One such organizational form is transdisciplinary centres, which facilitate collaborative efforts across disciplines. This article discusses the processes underlying the establishment and organization of one centre at the University of Gothenburg and another at Kiel University.

We define these centres as structures that enable diverse actors to engage in transdisciplinary research and education, fostering societal impact. Our particular interest lies in these two centres, given their focus on the ocean. The increasing international emphasis on ocean resources in relation to the Sustainable Development Goals (SDGs) heightens the need for academia to share knowledge about marine ecosystems and their relationship with human societies. At the same time, heightened economic interest in the ocean also poses risks, such as dispossession, loss of access to essential marine resources, and exclusion from governance processes (Bennett et al., 2021). These challenges present a compelling case for studying how universities can adapt to address sustainability-related issues.

Our reflections emphasize the processes whereby researchers have actively sought various pathways and models for societal interaction and impact, aiming to offer recommendations and identify potential pitfalls for future university models committed to sustainability. Sustainability's definition has evolved from a narrow environmental focus to encompass social and economic dimensions (Emas, 2015; Goodman, 1995; Porter & van der Linde, 1999). We recognize the diverse perspectives on this issue and adopt a comprehensive definition encompassing environmental, social, and economic sustainability to support sustainable operations. Furthermore, transdisciplinarity is characterized by its multiple interpretations. Here, we align with Strand et al. (2022), defining it as an approach that addresses complex challenges by engaging non-academic collaborators to create impactful solutions.

An essential consideration for the future is whether, how, and when universities seeking societal impact might face trade-offs between institutional development, integration with societal actors, and academic freedom. Van Looy et al. (2011) highlight that focusing on a single transfer mechanism may negatively affect others in the pursuit of impact.

Universities play multiple roles in developing and sharing knowledge in society, where two established routes are educating students and conducting research. Moreover, Hughes and Kitson (2012) proposed four societal interaction activities: people-based activities, community-based activities, commercialization activities, and problem-solving activities. Additionally, universities strive for a more direct societal impact. We propose at least three pathways to achieve such outcomes: (a) directly impacting society through research commercialization and spin-off ventures, (b) supporting public policy development, and (c) encouraging academic engagement through meaningful interactions with external actors. We argue that centres are a temporary organizational form that supports these three pathways while simultaneously enhancing the quality and quantity of research and education. We use these pathways to examine institutional building in the form of university centres.

Societal pressures on universities to adapt makes the topic of their societal impact particularly important. Concurrent with the expanding research on university–society interaction, expectations from international communities have intensified, urging universities to contribute to both economic growth and social development (Smith, 2007). These pressures take various forms, such as the UN SDGs and initiatives like the European Universities Initiative, which aim to enhance the capacity of European universities to achieve significant societal impact (e.g., On a European strategy for universities, 2022).

How, then, can universities of the future engage meaningfully with society and contribute to sustainability? We address this question by analyzing centres designed to balance individual initiative with structured interaction and communication. In Section 2, we first introduce the concept of university impact and its traditional interpretations. In Section 3, we discuss our methodological choices, combining case studies with reflexivity drawn from our experiences. Sections 4 and 5 describe the two transdisciplinary centres' cases. In section 6 we compare and contrast the cases with an emphasis on transdisciplinarity. In section 7, we discuss the cases in relation to our own experience and reflect on three trade-off situations universities encounter when organizing centres. Lastly in section 8, we lift the discussion to what we can learn for the future university from the cases and similar centres.

2. University Impact

Much of the policy recommendations and prior research on university–society interaction have primarily focused on the first pathway: achieving a direct societal impact through the commercialization of research and technology transfer from universities to industry. This approach, encompassing commercialization and technology transfer via patents, technical innovations, and academic entrepreneurship, is vital for economic growth and societal welfare. Various research streams highlight the significance of entrepreneurship, particularly university spin-offs, in fostering economic development (Barbero et al., 2012; O'Shea et al., 2005). Some studies even connect entrepreneurship to democracy by examining counterfactual scenarios where democracy was replaced (e.g., Germany in the 1930s and the rise of trusts in late 19th-century America), noting a sharp decline in entrepreneurship during those times (Audretsch & Moog, 2022). They argue for a deeper exploration of the relationship between entrepreneurship and democracy, suggesting that policies promoting one can also safeguard the other. Policies promoting democratic practices, such as distributed decision-making and self-sufficiency, could thus be mutually beneficial.

This first pathway of societal impact through commercialization and technology transfer has been widely adopted in the US, as well as in Sweden and Germany. Both universities and nations have developed this pathway by establishing various support structures, including incubators, accelerators, public funding bodies, and educational programs focused on innovation and entrepreneurship. Unlike universities in Germany and much of the world, Swedish universities do not retain the rights to commercially viable research results; instead, these rights belong to individual researchers (Arbetsmarknadsdepartementet, 1949). Nevertheless, the University of Gothenburg, along with most Swedish universities, has created functional organizational structures to facilitate this process within the national institutional context over the past few decades (Brunnström, 2021).

Additionally, more complex models of how universities can impact society have emerged, which introduce two additional pathways for consideration. The second pathway involves supporting public policy and

institutions by advising governments on viable strategies to achieve specific objectives. Universities can adopt more dynamic and transformative roles by fostering both internal and external competencies that support entrepreneurial initiatives through governance and public policy (Klofsten et al., 2019). The third pathway pertains to academic engagement, which, although previously overlooked, has gained prominence as a critical lens through which to understand how universities can influence society over recent years (Perkmann et al., 2013, 2021). Academic engagement is defined as knowledge-based network relationships between universities and external stakeholders. While academic engagement encompasses teaching, research, and commercialization activities, the same individuals and groups often contribute to all three domains. The literature on academic engagement emphasizes the autonomy of individual researchers; however, the impact pathways can adopt various forms and involve different external actors. Furthermore, Hughes and Kitson (2012) identify four types of societal interaction activities: people-based activities, community-based activities, commercialization activities, and problem-solving activities.

In this article we are interested in community-based activities (Hughes & Kitson, 2012) and in particular university centres. Therefore, this study investigates the preconditions, foci, and outcomes in education, research, and third mission activities, of two such centres to provide insights into how universities may organize to meet rising challenges and demands. As such, the body of research on academic engagement acknowledges that many instances depend on a combination of individual incentives and institutional support structures to facilitate and promote impactful processes (Perkmann et al., 2021). These two cases provide us with a good opportunity to analyze these underlying processes and provide insights.

3. Methodological Choices

In this article, we adopt a practice-based approach to reflect on transdisciplinary university centres. This approach is inspired by Di Nauta et al. (2018), who integrated reflexivity with case studies. Our analysis is informed by interviews conducted at the two centres, supplemented by information from the centres' respective homepages, as well as by reflecting on our own experiences with transdisciplinary centres (see Conflict of Interests, for further details). We also draw methodological inspiration from West et al. (2019), who emphasize the importance of reflexivity in connecting theoretical knowledge with practical application. They argue that by reflecting on personal experiences and acknowledging the influence of one's positionality, researchers can engage more meaningfully with stakeholders and contribute to more impactful sustainability practices.

This article aims to present and analyze two cases of transdisciplinary university centres focused on ocean-related issues. We will discuss these cases and apply reflexivity to our own experiences in establishing, developing, and working at university centres. This reflection, together with the insights gained from the cases, will allow us to conceptually propose ways in which such centres can play a more significant role in addressing sustainability challenges, particularly within the context of ocean solutions. In Table 1, we describe the interviewees and their positions within the respective centres.

As shown in Table 1, the interviews were conducted via Zoom (recorded and transcribed) or through email. The interviewees, ranging from senior scientists to directors, are deeply familiar with the centres and, in many cases, have been involved since their inception. The semi-structured interviews—whether conducted on Zoom or via email—combined both open and closed questions, allowing the respondents the flexibility to elaborate

Table 1. List of interviewees, their position, centre, date and type of interview conducted.

Interviewee	University/Centre	Date of interview	Type of interview
Person A, Gothenburg	University of Gothenburg/Centre for Sea and Society	26/6/2024	Email
Person B, Gothenburg	University of Gothenburg/Centre for Sea and Society	3/11/2024	Email
Person C, Gothenburg	University of Gothenburg/Centre for Sea and Society	6/11/2024	Email
Person D, Kiel	University of Kiel/Center for Ocean and Society	25/6/2024	Zoom
Person E, Kiel	University of Kiel/Center for Ocean and Society	25/6/2024	Zoom
Person F, Kiel	University of Kiel/Center for Ocean and Society	11/11/2024	Email

on their reasoning and provide examples. Following Yin (1994), we developed an interview guide to ensure that key topics were addressed, while also allowing the conversation to evolve in response to the interviewees' insights. The key topics of interest include:

- How the organization was created.
- What the foci of the organization are.
- What outcomes in terms of education, research, and third mission activities have they achieved.

We have compared the two centres by analyzing their respective preconditions, foci, and outcomes in education, research, and third mission activities. This comparative approach offers a comprehensive view of each centre's operations and impact. It not only deepens our understanding of their strengths and challenges but also contributes to the broader discourse on enhancing higher education systems. By drawing on these insights, stakeholders can make informed decisions that improve the overall effectiveness and societal relevance of university centres.

In Sections 4 and 5, we present the results of our analysis of the two centres—one at the University of Gothenburg in Sweden and the other at Kiel University in Germany—based on the interviews as well as supplementary documentation (e.g., annual reports and website content). In Section 6, we provide a comparative analysis of these two cases.

4. Centre for Sea and Society (University of Gothenburg)

The University of Gothenburg holds a leading position in marine transdisciplinary research and education in Sweden. Alongside cutting-edge infrastructure and expertise across a wide range of research areas, the university actively contributes to delivering knowledge, competence, and solutions that are in high demand by societal actors in both business and public organizations. In 2015, the university launched the Centre for Sea and Society (hereafter the Centre) by a decision of the vice-chancellor, with the aim of promoting collaboration between researchers interested in the ocean, society, and the relationship between the two. This account follows the first nine years of the Centre's development, during which the university made a strategic decision to invest in promoting societal impact within this field.

The Centre operates with a small secretariat comprising directors, project coordinators, and communication officers. It is governed by a cross-faculty steering group that includes representatives from all faculties and is administratively hosted by the Department of Marine Sciences. Today, more than 250 transdisciplinary ocean-related researchers from all eight of the university's faculties, spanning a total of 28 different departments, are linked to the Centre.

4.1. Preconditions

A key premise of the Centre has been the recognition that researchers with expertise in specific disciplines must work in a transdisciplinary manner. In addition, it is necessary to develop skills and competencies in transdisciplinary methods (e.g., how to connect people, groups, societies, and knowledge fields) and in sustainability science more broadly.

Prior to the Centre's launch, the university struggled to secure several large ocean-related research grants, despite having the strongest marine research in Sweden, particularly in the natural sciences, across all eight faculties. The Centre was therefore tasked with initiating, stimulating, and developing transdisciplinary research and education in the area of sea and society. It was also given the responsibility of establishing a main entry point for all marine and maritime activities at the university, thereby increasing its visibility. Additionally, the Centre was instructed to strengthen collaborations with regional partners such as Chalmers University of Technology and Region Västra Götaland and to represent the university in regional, national, and international collaboration platforms. The Centre's launch coincided with the UN Summit in New York in 2015, where Agenda 2030 was introduced, underscoring the need for diverse academic and non-academic competencies to address global challenges.

4.2. The Foci of the Centre

The Centre's primary role is to initiate and promote transdisciplinary marine research by creating activities and platforms that enable researchers from different disciplines and faculties to engage with each other and with actors outside academia. This is primarily achieved through physical and digital meetings, events, research support, and matchmaking. In summary, the Centre's mission can be described through three key objectives:

1. Supporting marine-related research across all eight faculties, including both established research groups and departments not traditionally associated with marine research, but interested in initiating projects in the area of sea and society.
2. Initiating, inspiring, and promoting interdisciplinary and transdisciplinary collaborations aimed at attracting research funding.
3. Providing a platform for collaboration and cooperation between researchers and societal actors outside academia.

Despite the Centre's well-defined role, one of its founders expressed the following concerns:

> So, the initiative was clearly from the vice-chancellor—and it is now a bit depressing to see that the following 2 vice-chancellors have not been interested in supporting this centre. I think one problem is

that this is not a centre of the type [research centre] and so it should now fall under the centre policy of the university which is more aimed at research centres. (Person B, Gothenburg Centre)

This quote explains the difficulties in having a centre that does not do the research itself and interacts with non-university actors as well. Furthermore, it highlights the challenges faced by transdisciplinary centres, particularly when confronted with demands from university management.

4.3. The Outcomes of the Gothenburg Centre for Sea and Society

The Centre identifies its most significant achievement as creating opportunities for researchers from various disciplines and faculties to connect with each other and with external societal actors. The Centre has built a network across the University of Gothenburg, linking researchers from all faculties and departments with different competencies. This has led to an increasing number of researchers reaching out directly to each other and key actors in business and public organizations, reducing the need for introductory meetings. The director of the Centre noted:

> We are regularly involved in and coordinate University of Gothenburg's representation and participation in various third-mission activities and platforms with the aim of increasing ocean literacy. This includes forums where science is communicated to policymakers, the public, or specific societal interest groups. A particular example worth highlighting is our continuous work within different projects where work with schools to increase the ocean literacy of young people using new and often innovative methods. (Person A, Gothenburg Centre)

This quote demonstrates the Centre's efforts to promote societal impact, particularly through ocean literacy, where the public benefits from knowledge about the ocean. However, measuring the full extent of this impact remains a challenge.

Long-term collaborations with platforms such as the Swedish Institute for the Marine Environment, the Maritime Cluster of West Sweden, and the Kristineberg Centre for Marine Research and Innovation have fostered close links to maritime industries and formal management organizations, particularly in West Sweden, but also nationally and internationally. The ability to manage and administer transdisciplinary projects and events is another key outcome of the Centre's work, encouraging individual researchers to engage in transdisciplinary activities.

One of the founders of the Centre shared the following thoughts regarding its communication activities:

> Over the past years, the Centre has put a lot of effort into research communication and activities. If I should be a bit critical here, I still believe this part has not been more successful than what you can expect from communication happening within intradisciplinary departments. The communication internally [through the newsletter] is good and still fills up the demand of sharing information among disciplines; there is also a seminar activity that bridges disciplines. However, I often compare it with the Stockholm University Baltic Sea Centre which has been very successful in reaching out to society with a lot of outreach activities [such as, policy briefs, Baltic Sea breakfasts, seminars for stakeholders, webpage for the public and school, etc.] I think we should be able to match them better in this, but this has so far not happened. (Person B, Gothenburg Centre)

This quote underscores the challenges faced by the Centre in effectively communicating its research and activities, which is a key aspect of its societal impact.

Another outcome of the Centre's work has been its involvement in transdisciplinary PhD programs:

> I also consider the research school at least partly very successful. Some of the PhD students [that] came out were really trained very much broader than the usual students and were "preadapted" to become active in solving societal challenges, either in continuing doing research or being hired by authorities. Some of the students failed, but I do not think that this was due to the school or the supervisors, but perhaps that they had other problems. I still think that University of Gothenburg should have continued to fund these very broad multidisciplinary PhDs because it was rather unique both globally and internationally. (Person B, Gothenburg Centre)

Although the results from the initial transdisciplinary PhD program were mixed, the interviewee emphasized the importance of the initiative. Several of these students have continued their academic careers or taken up positions in government agencies or as consultants, publishing transdisciplinary academic papers. A new transdisciplinary PhD program launched in 2021 incorporates lessons learned from the previous program, with 3–4 students from diverse backgrounds working together on joint projects. As the following quote shows:

> Several of them have continued their academic careers or have qualified positions within government agencies or as consultants. They have published several transdisciplinary academic papers. One development of the first round was the new transdisciplinary PhD Programme that started in 2021. The experiences gained from the first attempt have led to the new education having 3–4 PhD students with different backgrounds work in a joint project. (Person C, Gothenburg Centre)

This quote illustrates the Centre's commitment to learning from its experiences and evolving its approach.

Moreover, the Centre for Sea and Society have become an increasingly important conduit for the University of Gothenburg's involvement in larger EU and international research programs. These initiatives are often not driven by individual researchers but by larger networks and consortia. Participation in research networks such as the European Marine Board, Submariner Network, EuroMarine, and Mare facilitates engagement with EU and UN bodies, and formal international organizations like ICES, provide opportunities to influence funding calls. Initiating and fostering collaborations with decision-makers in Brussels, Stockholm, and various agencies and formal organizations, as well as in the maritime business sector, is important not just for individual researchers but for the university as a whole. These opportunities could otherwise fall through the cracks, as it is difficult for individual researchers to stay updated and involved in international research organizations.

5. The Center for Ocean and Society (Kiel University)

The Center for Ocean and Society (hereafter the Center) is hosted by Kiel University, Germany, and was established in 2020. The Center is part of Kiel Marine Science (KMS) which in turn has around 70 working groups focused on maritime and blue research. The Center operates out of its facility and currently employs 30 staff members, including student assistants.

5.1. Preconditions

The idea for an ocean research centre at Kiel University began to take shape in 2017 when the university applied for funding through the German Government's Excellence Initiative, aimed at making German universities more competitive internationally and implementing the EU Lisbon Strategy. While Kiel University's proposal for this funding was not successful, the government nonetheless provided funding through other means:

> So, the proposal was submitted for the cluster of excellence and then something happened, which nobody expected. The proposal was not funded. But the money was there to establish the key ocean assessment and solution centre. (Person E, Kiel Center)

The Center officially began operations in March 2020, coinciding with the onset of the Covid-19 pandemic and the restrictions imposed by the German government.

5.2. The Foci of the Center

The Center promotes marine and blue research and belongs to KMS which works across all 70 working groups at Kiel University, which represent all faculties except theology. The Center is coordinating project development between these working groups and facilitating transdisciplinary research established at KMS. Until now, this position is project funded. This transdisciplinary and coordination focus is described by one interviewee:

> By training, I'm a chemist, but in my function here, I am the coordinator for transdisciplinary research. So that means my job is mainly building up networks and supporting networks between academic working groups here from the marine research at Kiel University and stakeholders outside the university like ministries, administration, maritime business, or non-governmental organizations. So, in a very broad sense, societal stakeholders. (Person D, Kiel Center)

The Center focuses on three main research areas:

1. Marine and coastal resource economy.
2. Marine and coastal geohazards.
3. Marine food security.

5.3. The Outcomes of the Center

An example of an output of the Center is the SeaRanger project, mutually developed by a local fishing cooperative, authorities, and researchers. The project aims to diversify the fishing profession with tasks in nature conservation, public relations, and ecosystem management. An outcome of this collaboration is a project that involves local fishermen in monitoring algae blooms while also increasing their knowledge base:

> But that's something of a new professional pillar for them to become part, to do some research on with their fishing boats. (Person D, Kiel Center)

This project exemplifies the Center's commitment to working with external stakeholders.

The Center also contributes to a master's course in transdisciplinary research, attended by around 15 students each year, drawn from diverse educational backgrounds across the university's faculties. The course aims to introduce students to transdisciplinary research and demonstrate its benefits. As part of this, they also involve non-academic actors such as non-governmental organizations from the environmental sector and people working in the Ministry for Environmental Affairs. They also promote transdisciplinary research by:

> Including non-academic actors like non-governmental organizations from the environmental sector or involving people working in the Ministry for Environmental Affairs and including them in the teaching. That's also a kind of transdisciplinary activity. (Person D, Kiel Center)

In addition to running their own transdisciplinary projects, the transdisciplinary coordinator supports other KMS members in developing and running transdisciplinary projects. The Center is also involved in numerous KMS external networks focused on transdisciplinary research and funding, such as the Global Alliance for Inter and Transdisciplinarity.

Similar to the Centre at the University of Gothenburg, Kiel's Center lacks a set of standardized indicators for monitoring its activities. As one person at the Center noted:

> While we do monitor that transdisciplinary activities are ongoing, there are no indicators or objectives in terms of numbers (yet)….How [does] a good indicator look like[?] It is always "what gets measured, gets done," and especially with transdisciplinary projects, it is so much about quality and less about quantity. (Person F, Kiel Center)

This quote reflects the challenges both centres face in measuring and monitoring the outcomes of their transdisciplinary work.

6. Analysis

The two cases have highlighted what the centres at the University of Gothenburg and Kiel University do, how they were set up and the key benefits of having centres. In Table 2, we outline similarities and differences between the two centres, derived from the interviews and complementary material.

As shown in Table 2, the core attributes of both centres are similar, particularly in their shared ambition to renew the universities and enhance their interactions with society. However, there are notable differences in the specific details of their missions and operations. The Center for Ocean and Society primarily promotes and hosts transdisciplinary research, and is only involved in education through its members. In contrast, the Centre for Sea and Society has a slightly broader mandate, supporting, enabling, and communicating marine and maritime research and education across all departments and faculties within the university.

Table 2. Comparison table: focal centre and comparison centres.

Factor	Sea and Society (Gothenburg)	Ocean and Society (Kiel)
Preconditions	Cross-faculty centre with approximately 250 affiliated researchers, funded by the university and mandated by the vice-chancellor. The centre also has external funding for specific projects	Coastal and ocean research is a designated focus area of Kiel University. The centre is a part of KMS, which involves 70 working groups engaged in maritime and blue economy research. Kiel's centre has permanent funding from the university, granted by the German state government, but also has external funding for specific projects
Foci	Supporting marine-related research across all eight faculties	Coordinate transdisciplinary research about coasts and the ocean
	Initiate, inspire, and promote transdisciplinary research	Involve external stakeholders in transdisciplinary research projects
	Providing a platform for collaboration and cooperation between researchers and actors outside academia	Promote research at the centre's three focus areas: marine and coastal resource economy, marine and coastal geohazards, and marine food security
Outcomes (education)	Master's program	Contributes to a Master's course on transdisciplinarity
	Nordic master's programme (hosted by Swemarc)	
	Trans and interdisciplinary courses at the master's and graduate level promoted	
Outcomes (research)	Linking researchers from different disciplines	Good practice guide for transdisciplinary research in marine sciences
	Enabling research collaborations across disciplines	Glossary on transdisciplinary methods
	Intermediary	Support in the coordination of research applications and projects spanning all the university's faculties
	Stimulate excellent research	Linking researchers from different universities
		Promoting transdisciplinary research at Kiel University
		Stimulate excellent research
Outcomes (third mission)	Part of public-private projects	Organizing workshops
	Coordinating efforts	Living labs encourage dialogue between researchers and societal actors and where the public can interact with ocean-related research
	Communicating research publications directly to policymakers, media, and civil society	

The two centres are funded through the university's central budget, as well as additional project funding. Both centres face challenges in monitoring and evaluating their societal impact, particularly in defining appropriate outcomes and recurring indicators. Nonetheless, both centres produce or contribute to annual reports and undergo evaluations to ensure transparency and secure continued project funding.

Both centres focus on transdisciplinary projects and societal interaction, though they engage with these elements in different ways. The Kiel centre places significant emphasis on external stakeholders and transdisciplinary research, a focus that has influenced the broader direction of Kiel University, which now actively promotes transdisciplinary research across all faculties and priority areas. The permanent core funding for research of the Kiel centre provides it with unique conditions to engage in long-term projects, setting it apart from the Gothenburg centre, where funding is sought continually, and the management must regularly justify its relevance to university leadership. From our interviews, we have identified four main challenges the two centres face.

First, promoting cooperation across faculties and departments, while also fostering collaboration with societal actors, is a challenging and time-consuming process that requires focused communication and trust-building. While the Gothenburg centre has made significant strides in overcoming obstacles to transdisciplinary collaboration, there remains a need to identify further barriers and establish reliable pathways and routines for facilitating this approach within the university.

Second, the traditional structure of a university is not always conducive to fostering cross-faculty or cross-disciplinary collaboration, nor is it always structured to engage effectively with external societal actors. It has been necessary to develop new administrative pathways to support the university's marine and transdisciplinary profile, as well as to inform the administration about the potential for such collaborations. The creation of the new master's program in sea and society would not have been possible without innovative administrative support and collaboration from leadership across faculties, departments, and the central administration.

Third, frequent changes in university leadership, with new leaders bringing in their own ideas about how to organize academic departments and university profiles, further complicate the situation. Often, new leaders are reluctant to take responsibility for decisions made under previous administrations. Additionally, many individual researchers lack the motivation or time to engage in processes that serve the common good, as the immediate personal benefits to their academic careers are not always clear.

Fourth, in February 2023, the vice-chancellor of the University of Gothenburg decided to include marine research as one of the university's five core profiles. This decision is expected to enhance the university's visibility and strengthen its position in the non-academic world. Researchers working at the centre are building strong networks both within and outside the university, which can be personally rewarding. However, there remains some hesitation about the advantages of complementing traditional disciplinary work with transdisciplinary research, particularly when building an academic career. The outcomes of transdisciplinary work are often difficult to measure in terms of tangible metrics such as publications or funded projects, as the centre itself does not necessarily own the projects.

As a university with the vision of becoming an internationally recognized academic institution, committed to shaping the future and contributing to a sustainable world, there is a clear need to bridge the gaps between faculties, departments, and disciplines. Facilitating collaboration across these boundaries, while also engaging with external societal actors, will be crucial in achieving this vision.

7. Discussion

In the following discussion, we reflect on the two centres and our own experiences within similar centres in Sweden. Our aim is to contribute to ongoing debates regarding the governance and effectiveness of such centres, both specifically in the context of the University of Gothenburg and Kiel University and more broadly for universities investing in these centres or hubs as organizational forms to create societal impact. We view these impacts as trade-offs between various ways of influencing society and designing research.

7.1. Encountering Trade-Offs

Based on our reflections, we have identified three key trade-offs that are inherent in the operation of transdisciplinary centres. These trade-offs highlight critical issues regarding centres as an organizational form, with accompanying benefits and potential drawbacks.

7.1.1. Funding Transdisciplinary Centres

A common criticism is the opportunity cost of funding transdisciplinary centres, i.e., why allocate resources to centres rather than enhancing existing university structures? Critics might argue that investing in centres diverts funds from core university missions, such as research and student education, which could be more directly impactful in strengthening the university's primary activities.

However, we argue that one of the key advantages of centres lies in their ability to build networks—both internal (within the university) and external (with international institutions, companies, and public organizations). These networks can facilitate large-scale projects and drive impact. Centres also help develop the skills needed to coordinate complex projects and foster collaborations that might not be feasible within traditional departmental structures. While there is a risk that these investments benefit only a few individual researchers or departments, over time, the university may secure additional funding and opportunities for broader societal impact.

7.1.2. Parallel Structure vs. Line Structure

Another trade-off arises from the potential tension between the centre as a parallel structure and the university's core (line) structure. Centres may pull key people from their primary responsibilities in departments or faculties to work on transdisciplinary initiatives, potentially undermining the university's core functions.

Nevertheless, we believe that centres can complement and even enhance the work of the line organization. For example, centres can contribute to new educational programmes that bring together transdisciplinary knowledge, foster international connections, and provide a forum for idea-sharing among researchers. The demand for professionals with transdisciplinary knowledge has driven the development of such programmes. However, if centres become more attractive to researchers than their original departments, there is a risk of "brain drain," where key disciplinary expertise is drawn away, weakening the university's traditional academic structures.

7.1.3. Limits to Societal Impact

While transdisciplinary centres are granted resources and attention, their ability to address complex societal challenges remains uncertain. Sustainable development research and the UN's Agenda 2030 require collaboration across disciplines and with external societal actors.

Centres such as Sea and Society and the Center for Ocean and Society have a strategic role in facilitating collaborations between academia and industry or public organizations. The increasing desire of societal actors to engage with researchers has spurred the development of transdisciplinary academic environments. Yet, the different academic cultures, administrative rules, and research practices across various parts of the university present significant challenges. These barriers take time to overcome, and trust-building is essential for fostering effective collaborations. Centres have the potential to play a critical role in this process by acting as bridges between different university faculties and external stakeholders. However, for some urgent societal challenges, non-university research organizations—being more flexible and responsive—may be better equipped to respond swiftly to collaboration requests.

7.2. Reflections on Centres as an Organizational Form

In recent years, funding opportunities for transdisciplinary research have increased, largely in response to the growing recognition of complex societal challenges, such as those articulated in the UN SDGs and the UN Decade of Ocean Science for Sustainable Development. The EU's increasing focus on mission-oriented projects has also influenced national funding bodies. Centres can play a key role in connecting researchers to funding opportunities, facilitating collaboration, and providing support for the development of new projects. This role, while crucial, can be difficult to quantify, as it often involves activities that are not directly linked to measurable outputs like publications or funded projects.

Centres may have a formal role in contributing to strategic discussions at the university, but they could benefit from more regular consultations to leverage their expertise, contacts, and resources. Economic resources and dedicated staff have been essential for centres to respond to requests for collaboration, fund memberships in key international organizations, and host international guests. There is a clear need for university-wide functions that can act as integrators, connecting the many individual components of the institution.

Centres also serve as temporary organizations designed to leverage the strengths of the existing university structure. They bring together individuals and groups around a common theme, and their temporary nature means they have a defined beginning and end. Many of the benefits from these centres accrue to the individual researchers and students involved, and by extension, benefit the university's core research and teaching activities. The value of these centres lies in their ability to renew university activities, mobilize capabilities, and respond to emerging opportunities, although the university as a whole must empower individual researchers to take advantage of these opportunities.

8. Conclusion

Universities have numerous ways to impact society, and their potential to contribute to global challenges, particularly those related to the ocean and its ecosystems, is increasingly recognized. The demand for

academic expertise on ocean issues is growing, driven by the need to achieve the SDGs. Building on the four societal interaction activities proposed by Hughes and Kitson (2012)—people-based activities, community-based activities, commercialization activities, and problem-solving activities—we suggest a fifth category: policy and institution-building activities.

We argue that the main benefit of centres as an organizational form is their ability to sustain relationships with both internal and external actors, serve as competence hubs for international transdisciplinary projects, and inform policy by aggregating knowledge from across university disciplines. Centres such as the Center for Ocean and Society in Kiel and the Centre for Sea and Society in Gothenburg exemplify these benefits. However, we also recognize inherent challenges, which can be summarized in the three trade-off situations discussed in Section 7.1.

These trade-offs reflect some of the negative consequences of organizing research in transdisciplinary centres, including the personal uncertainties faced by researchers involved in transdisciplinary projects—uncertainties about both the outcomes of their work and the publishability of their results. For the centres themselves, there are also difficulties in measuring and communicating the societal impact of their activities.

In conclusion, universities must learn from past experiences and prior efforts to create meaningful societal impact. We believe that universities should draw on their traditional strengths (specialized research and education) while also adapting to meet contemporary challenges and societal expectations. One crucial lesson for the future university is the importance of creating an environment that fosters creativity and responsiveness. This includes streamlining decision-making processes, allocating resources to support emerging initiatives, and continuously connecting knowledgeable colleagues across disciplines. By doing so, universities can build networks and allocate resources that will enable individuals and groups to tackle the complex challenges of our time and create lasting societal impact.

Conflict of Interests

Lena Gipperth and Linus Brunnström are members of the Centre for Sea and Society and Lena Gipperth was its director from 2015–2022, while Linus Brunnström was part-time employed as a project coordinator 2021–2022.

Data Availability

The data used in this article were collected in the form of interviews with key actors in each transdisciplinary centre and supplemented by information gathered from their respective homepages.

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