Chapter 2
Knowing the Ocean: Epistemic Inequalities in Patterns of Science Collaboration

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Abstract Ocean governance requires us to know the ocean. However, the knowledge systems that have shaped how and why we know the current ocean have been historically limited. In the present, they often subdue other knowledge systems that, if and when recognized and included into governing processes, not only move towards social justice and inclusion but can also improve decision-making and practical outcomes. The concept of epistemic inequalities encapsulates the disparities between different ways of knowing and their influence in ocean governance. For example, since the rise of colonial Europe, European-centric white male ideologies have long dominated global development practices. Within science, some disciplines have substantially more power than others, represented by funding and policy influence. In turn, local and indigenous knowledge systems, feminist ideologies and a broader range of highly valuable ways of knowing and doing in the sciences are far from equally participating in shaping ocean development discourses, decision-making and governance processes affecting the future of ocean sustainability. This chapter provides a theoretical basis for unpacking such epistemic inequalities in ocean governance, and thus setting a foundation for critically reflecting on the context and knowledge within the chapters of this book.

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2.1 Introduction to Knowing & Governing Our Ocean

Governing our ocean requires us to know them: their structures, functions, internal processes, the resources and services they provide, as well as their carrying capacities, stressors and triggers of change. In-depth research forms the basis for our use, management and governance of the ocean, as well as how those actions shape sustainability outcomes (Campbell et al. 2016; Partelow et al. 2020b; Rudolph et al. 2020). However, these are not the only influences. Millennia of experiential knowledge of our marine and terrestrial ecosystems are embedded in our cultural practices, stories and ethics across coastal societies in the form of local and Indigenous knowledge (Drew 2005; Martin et al. 2007). Numerous studies have now shown the benefits of marine and coastal governance and management outcomes when knowledge integration can be achieved between different scientific, local, traditional and Indigenous knowledge systems and integrated in decision-making (Alexander et al. 2019; Porten et al. 2021; Poto et al. 2021). Nonetheless, epistemic inequalities remain widespread in ocean governance in terms of what types of knowledges are recognized, valued, supported and utilized as a form of power to inform decision-making.

How we know the ocean varies substantially around the world with regard to the respective ecosystems at hand, level and scale, disciplinary perspective, geographic area, method of data collection and analysis as well as with which thematic foci we approach the ocean. What individuals, communities and societies regard as knowledge or 'non-knowledge', and by that, what is worth knowing, protecting, sharing and further developing, represents different forms of past, present and future realities. Thus, how people see and read their realities and environments is determined not only by hypothesis testing and empirical positivism, but also by processes of meaning-construction and sense-making. These processes in turn shape societal norms, rules, and institutions. However, the sequence of effects also works in reverse through institutional structures – and the materialities those have resulted in – influencing processes of sense-making. While this ensures global diversity in engaging with earth systems, and in knowing and governing them, substantial global imbalances prevail in the systematic scientific assessment of local and regional ecosystems, with respective effects on how we globally know and can locally govern our earth systems.

The United Nations (UN) 2030 Agenda for Sustainable Development, and especially the Sustainable Development Goal (SDG) 14 'Life below Water – Conserve and sustainably use the worlds ocean, seas and marine resources for sustainable development' – marked a paradigmatic shift in the ways in which life on earth, whether terrestrial or aquatic, is to be globally valued and sustained. There is increasing awareness of the relevance of ocean-related science in the context of sustainable development, framing the biosphere as the base for all other SDGs in the ocean-climate-biodiversity nexus. Furthermore, the overall production of global ocean science is increasing (IOC-UNESCO 2017, 28). However, the ocean is not yet sufficiently included in concepts of sustainable development, particularly

concerning interlinkages, synergies, circular processes and trade-offs. This lack in mainstreaming ocean-related issues leads to underestimating given opportunities of ocean science in terms of narratives, models, theories of change and monitoring. The UN has declared 2021–2030 as the UN Decade of Ocean Science for Sustainable Development, with the tagline "The Science We Need for the Ocean We Want", addressing the many off-track indicators under SDG14 and challenges of ocean-related science. There are seven envisioned outcomes of the Decade, with the last entitled as 'An Inspiring and Engaging Ocean'. This explicitly supports the development of transformative ocean science as a means for globally fostering ocean literacy, meaning a thorough understanding of the ocean and its needs, in society. In doing so, the UN Ocean Science Decade refers to the Agenda 2030 as a guiding framework. Celebrated at the UN "Our Ocean" Conference in New York in June 2017, SDG 14 offers a global (while exclusive) platform for (re-)negotiating, overcoming and (re-)affirming hierarchies within and between different marine knowledge systems. Yet, what are marine knowledge systems? Furthermore, how are they characterized across different cultural and marine-environmental science contexts? In sum, what are these ocean knowledge systems that are being addressed by the UN Ocean Science Decade 2021–2030, and in particular by its aim to foster transformative ocean science and contribute to societal ocean literacy around the globe?

This chapter – in an overview manner – assesses these questions with regard to the ocean. How do we know the ocean? What characterizes the (largely) scientific and (less) non-scientific knowledge systems that engage with and study the ocean? Which infrastructures are in place, financed by whom? Which disciplinary organization do we find? Which thematic foci guide agenda setting processes and how basic versus applied are the questions asked and the answers given?

We reflect on these questions (1) by bringing together insights from the Global Ocean Science Report by the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization (IOC-UNESCO 2017), (2) by providing a synthesis of a series of review publications focused on analyzing the current state of marine science knowledge in published literature in specific fields (Barboza and Gimenez 2015; Aksnes and Browman 2016; Kim et al. 2016; Costa and Caldeira 2018; Mazaris et al. 2018; Partelow et al. 2018, 2020a; Pauna et al. 2019; Syed et al. 2019; Tolochko and Vadrot 2021; Cesarano et al. 2021), and (3) through a discussion linking ocean governance theory and practice.

Based on these, we argue that substantial 'epistemic inequalities' (Wellmon and Piper 2017) exist with regard to globally knowing the ocean and immensely hamper any regional and global attempts of coordinated or collaborative ocean governance. A globally comparable knowledge base, required for the implementation of, for example, a 'Common Heritage of Mankind' principle for the seafloor, is not given – as confirmed in the United Nations Convention of the Law of the Sea for the Area Beyond National Jurisdiction. Alice Vadrot and colleagues even go as far as arguing that the international world order is being contested through the principle in the field of marine biodiversity (Vadrot et al. 2021, 2022). As the challenges of our earths' ecosystems nevertheless require coordinated and collaborative global responses in the twenty-first century, the UN Ocean Science Decade thus sees itself challenged

to overcome some of these immense inequalities in how we know the ocean and to create platforms for (a) substantially strengthening local and regional ocean knowledge systems, and (b) putting them in dialogue with each other on transregional and global levels. As we argue below, a solid and transregionally nurtured and anchored knowledge base with regard to the ocean is absolutely necessary for Ocean Governance in the coming years.

2.1.1 Knowledge System Diversity

Substantial scholarly work exists, assessing the manifold nature of different epistemic cultures and knowledge systems in subsistence and larger-scale agriculture in developing contexts (Wall 2008; Sanginga et al. 2009; Hornidge and Antweiler 2012; Hornidge et al. 2016). These works empirically document and analyze the interrelationships between high nature dependency in situations often characterized by rural peasant lifestyles, high social inequalities, and local ecology-related knowledge systems. However, there is substantially less knowledge assessing marine ecosystems and fisheries-related knowledge systems in comparably rural, subsistence-level lifestyles in developing contexts (Bavinck and Verrips 2020). We know surprisingly little about the unique characteristics, internal logics, negotiation powers, and peculiarities of marine knowledge systems of marine ecosystem-dependent communities, and how they may differ contextually, which may not allow us to make assumptions about those knowledge systems based on what we know from terrestrial systems.

'Knowledge systems' is a term we understand with reference to Karin Knorr Cetina's concept of 'epistemic cultures' as "those amalgams of arrangements and mechanisms – bonded through affinity, necessity, and historical coincidence – which, in a given field, make up how we know what we know" (Knorr-Cetina 1999, 1). Knorr Cetina illustrates in her own work that these epistemic cultures include small, clearly defined environments of knowledge production, as well as larger and less clearly defined environments of these environments, their preconditions, and their characterising elements. Processes of meaning-construction and sense-making determine how we see and interpret our environments while ourselves being influenced by the environments that surround us. Based on these constructions, we then establish norms, rules, and a wide range of different types of institutions for regulating our everyday lives. With respect to what is regarded as meaningful and how, the processes of sense-making themselves are influenced by former inter-subjectively shared interpretations of reality, by the institutional structures and materialities they have resulted in, and by guiding actors in their everyday practices towards the realisation of future imagined realities. These insights into the social and communicative construction of reality from the sociology of knowledge perspective provide a foundation for research into particular knowledge systems (Schütz 1932; Berger and Luckmann 1966; Schutz and Luckmann 1974). However, they say little about the qualitative nature of these epistemic realities specific to particular environmental

contexts, or about the power structures shaping and shaped by them. This chapter thus aims to – in an overview manner – bring together insights on marine and ocean related knowledge systems as basis for ongoing discussions regarding transformative ocean science and the nurturing of ocean literacy in societies as part of the UN Ocean Science Decade 2021–2030. Below, we therefor seek to assess existing hierarchies and the contestation thereof of different stocks of marine resource-related knowledge in order to understand the underlying rationales, logics, and power interests in different subjective and objective interpretations of marine resource realities.

2.2 Synthesis of Ocean Science Knowledge and Capacities

2.2.1 Ocean Science Infrastructures

The Global Ocean Science Report by the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization (IOC-UNESCO 2017) globally assesses – for the first time ever – the status quo and current trends in ocean science capacity. By taking stock of who, how and where ocean science is conducted, the report states that "[t]he USA has the highest number of research institutions varying in size (p. 315) – roughly equal to the total number of research institutions in Europe combined and greatly exceeding the number of institutions operated in Asia and Africa". Assessing the type of researchers working in the field, the report interestingly states that the participation rate of female scientists in ocean research was 10% higher than the global share of female researchers across all natural scientific disciplines, and that they comprised on average 38% of all researchers across the marine sciences (p. 8). Underlining the importance of ocean science institutions, marine laboratories and field stations in more detail, the report identifies amongst the five largest Ocean science budgets in terms of percentage of national research and development funding those by the USA, Australia, Germany, France and the Republic of Korea (p. 27). The overall 784 marine field stations counted by the report are located in Asia (23%), Africa (8%), South America (10%) and Oceania (5%), as well as Europe (22%), North America (21%), and Antarctica (11%) (UNESCO-IOC 2017). Furthermore, the report counts 325 research vessels globally that were – at the time of writing the report – in operation and of which more than 60% belong to the Russian Federation, USA and Japan together. These range from 10 m to more than 65 m in length, with some built more than 60 years ago, while others have been in operation for less than 5 years. The average age of national fleets varies between <25 years (Norway, Bahamas, Japan and Spain) and >45 years (Canada, Australia and Mexico). As well, the report states that more than 40% of all research vessels focus on coastal research, while 20% engage in open ocean research (p. 26) (see Fig. 2.1).

The data collected for the report show differences in national stocktaking of the infrastructures and personnel in the sector. Despite these shortcomings they nevertheless indicate substantial differences in technological equipment and scientific

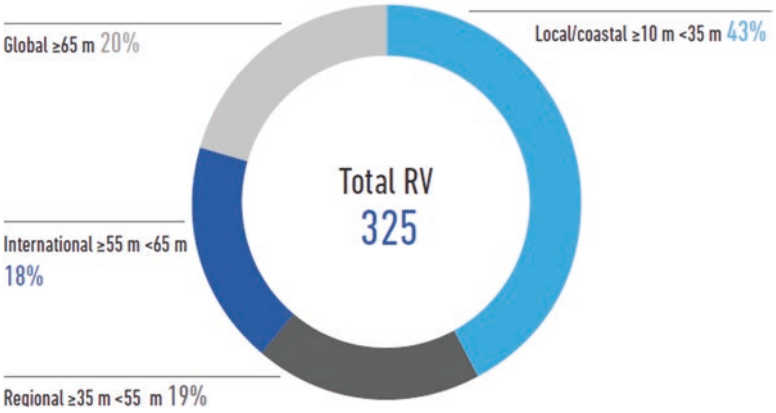

Fig. 2.1 Relative proportion of the different ship sizes summarizing all research vessels. (IOC-UNESCO 2017, 26)

capacity for studying the ocean. These differences in resources determine the knowledge production in the marine context due to varying capacities to actually conduct research on marine topics as well as differing access to specific research areas and equipment (e.g., research vessels, instruments for deep-sea activities and resource extraction). In addition, marine sciences are not bound to specific disciplines, but instead span the disciplinary range from natural to social sciences (Glaser et al. 2012; Markus et al. 2017; Partelow et al. 2018) with the common research objective of understanding coastal ecosystems, their functioning, use, management and governance, acting as a defining and uniting frame. Thus, specific knowledge systems and traditions shape ocean sciences and its research priorities. Due to existing hierarchies in knowledge production and sharing in the marine context, many actors worldwide are dependent on the research, which is conducted by the knowledge systems financed, organised and fostered by the above-mentioned nation states. These dependencies lead to international asymmetries, a limited range of databases and analyses, restricted access as well as gaps in our understanding of what the ocean is. This is not to say that the advancement and funding of research by the few dominant actors does not contribute substantially to global knowledge advancement, but rather that the interests and agendas of those states have taken precedent in shaping what we know, how we know, and what is done with that knowledge in a way that lacks global intellectual and cultural diversity. Furthermore, a few actors substantially influence the contextual insights that shape and fund what is valued, and thus pursued in practice, as a knowledge creation activity, as well as have control over who benefits from that knowledge and for what reason. In addition, we further know that prior knowledge shapes interest in what future knowledge creation pursuits should be. This is a form of path dependency, where past players largely control what we think is interesting scientifically, such as the research questions, methods and geographies, largely steering globally limited scientific

capital. This has, historically, been limited to a select group of states that has largely missed the knowledge needs and values of more diverse world regions, as synthesized below.

2.3 Ocean Science in Publishing: Collaboration Patterns Across Countries and Regions

Global knowledge about the ocean is not equal across space, time, thematic areas or disciplinary lenses. Nor is it even in who, how or where it is produced. In practice, ocean knowledge production exists within, and is reinforced by, interdependent networks of science collaboration (Barboza and Gimenez 2015; Aksnes and Browman 2016; Kim et al. 2016; Costa and Caldeira 2018; Mazaris et al. 2018; Pauna et al. 2019; Syed et al. 2019; Partelow et al. 2020a; Tessnow-von Wysocki and Vadrot 2020; Tolochko and Vadrot 2021). Transregional network patterns and the actors within them are iteratively co-shaping each of their roles (or lack thereof) in those networks, leaving a science system with substantial path dependencies (likely future trajectories guided by historic patterns) and epistemic imbalances (what is worth knowing, why and who benefits) in terms of who is able to produce and access knowledge (and on which topics). It can be argued that this creates and reinforces scientific partnerships largely driven by access to material and immaterial infrastructures such as finance, language, thematic expertise and networks (Partelow et al. 2020a, b). As shown below, the challenge of deconstructing those path dependencies to foster eye-level science systems with valued contributions built on robust cooperative networks within and between Global North and Global South science systems is a distant reality, but one with steady progress.

As a necessary step towards fostering more comprehensive ocean literacy (Marrero et al. 2019), and to move towards a more equal and just version of that literacy, a bibliometric understanding of current scientific literature is a necessary starting point. In a systematic review of peer-reviewed publications in the field of tropical marine science, Partelow et al. (2018) highlight the dominance of natural science publication output compared to the social sciences in nearly every world region, with Southeast Asia being relatively balanced (Fig. 2.2b). Similarly, the spatial distribution of knowledge about tropical marine regions is unequal. Far more knowledge exists on Southeast Asia and northern Australia (classified separately), followed by the Pacific Islands, Central America and the Caribbean. East African knowledge has a comparatively little share, but is far ahead of West African and Sub-Saharan African research which represents a substantial gap in global ocean science. Similarly, Liquete et al. (2013) review patterns of global marine and coastal ecosystem service research. They importantly highlight a large number of case studies in Northern Europe and North America, which are primarily being done by researchers from those countries. In contrast, they show that there are indeed case studies in Central and South America, Africa, the Pacific as well as South and

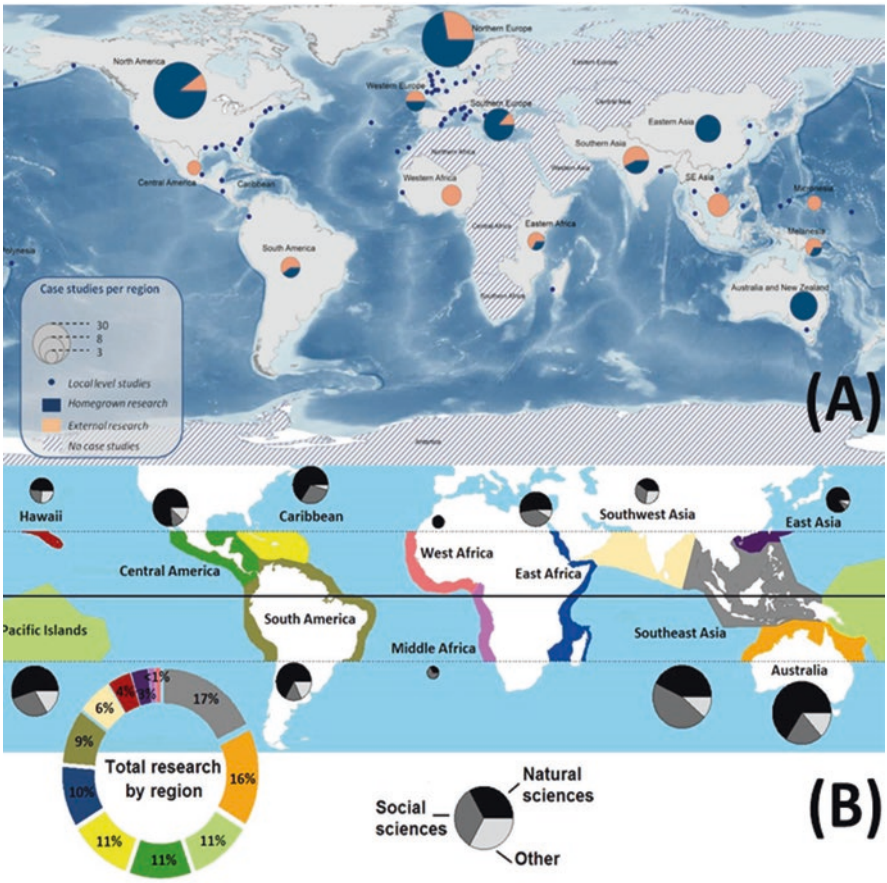

Fig. 2.2 (**a**) Spatial distribution of marine and coastal ecosystem service research taken from Liquete et al. (2013). Pie charts split by origin of research authors, domestic (blue) or external (orange). Most tropical research done by the UK and US. (**b**) Spatial distribution of tropical marine research taken from Partelow et al. (2018). Large knowledge gaps exist in West and Middle Africa as well as Southwest Asia

Southeast Asia, but the majority, if not all cases in those regions, are done by authors from outside those regions, predominantly the UK and US (Fig. 2.2a). Similar disparities have been shown in other global sustainability research areas, such as urbanization, where knowledge on the Global South is primarily produced by researchers in the Global North, although Global South sustainability challenges are fundamentally different (Nagendra et al. 2018).

The paradigmatic shift towards orienting both fundamental and applied science towards solving real world problems is an important driver for understanding patterns of emergent ocean literacy and discursive framing. This thematic area knowledge, or problem orientations, within the tropical marine sciences are also skewed. As a percentage of the literature, dominant social science problem framings are

conservation (30.9%), commercial resource use (19.7%), tourism (9.7%), pollution/degradation (9.0), subsistence resource use (7.9%) and none (5.6%). Dominant natural science problem frames are firstly, none (37.0%), followed by pollution/degradation (23%), conservation (10.9%) and commercial resource use (9.1%) (Partelow et al. 2018). Coral reefs dominate the ecosystem focus in the marine tropics, followed far behind by mangroves, estuaries/lagoons, intertidal ones, deep sea and others. In total, ~57% of tropical marine research is locally focused, compared to regional (36%) and global focused (7%). When split into specific scales, focus on ecosystem, spatial, management and temporal scale research far exceeds research on knowledge, institutional, jurisdictional or network scale research (Partelow et al. 2018). In addition, the majority of all research across both scale and discipline is skewed towards producing system knowledge (i.e., descriptive system functionality) with only a smaller subset of social science producing target knowledge (perspectives, values, goals) and transformative knowledge (actionable pathways for change). The more specific social and ecological system processes that tropical marine science has focused on are shown in Fig. 2.3.

Scientific collaboration networks can be measured using bibliometric data on co-authorship patterns as a broadly representative indicator of other formal and informal transregional cooperation. Drawing on data from Partelow et al. (2020a, b), co-authorship patterns in the field of tropical marine science are moving towards more international collaboration nearing 40%–50% of all peer-reviewed journal articles in 2016, 2017 and 2018, with domestic collaborations (all authors have the same country affiliation) increasing proportionally with the publication inflation rate over time. Single author papers have drastically decreased as a percentage of total output in tropical marine science research. Similarly, in the global fisheries

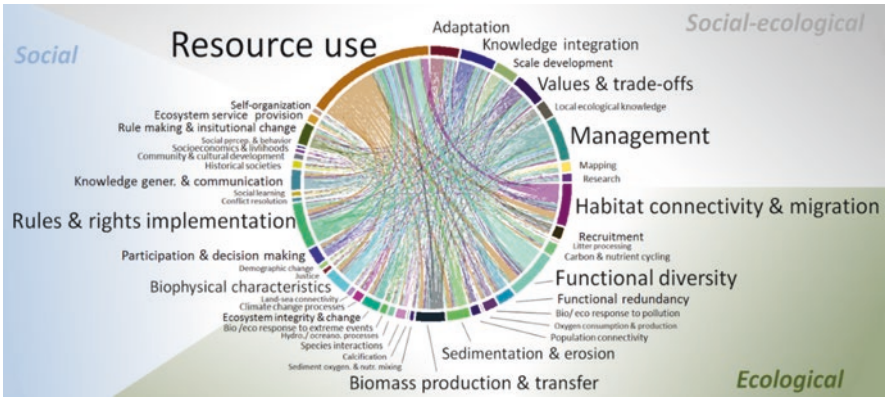

Fig. 2.3 Circle plot of the frequency and combined focus areas of publications that examine at least two system functions or processes, taken from Partelow et al. (2018). The proportion of the research focus that each process receives within multi- or interdisciplinary research is shown. This is visualized by the font size and the size of the colored segment of the circle. Also, process connectivity is shown. A connection between processes means that both processes were examined in the same publication

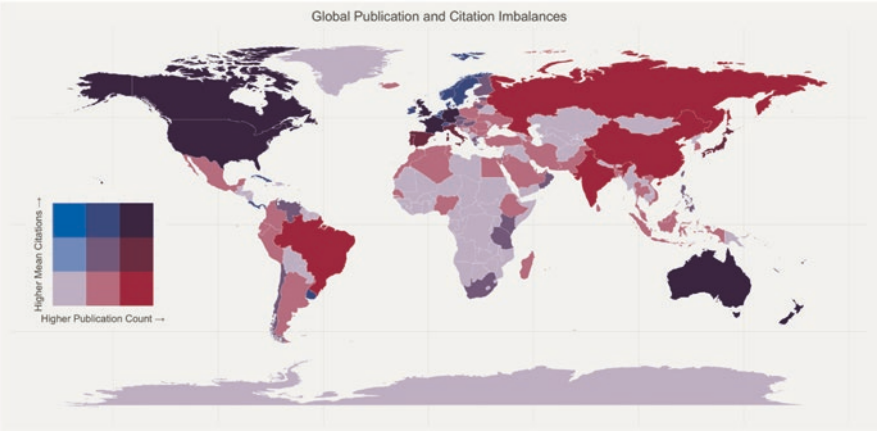

Fig. 2.4 Taken directly from Tolochko and Vadrot (2021), showing the geographic distribution of the total amount of articles and average citation count by country in English language peer-reviewed marine biodiversity literature between 1990 and 2018

science literature, Syed et al. (2019) provide a comprehensive analysis indicating that international collaboration outputs are increasing and single author outputs are decreasing. In the field of marine biodiversity research, Tolochko and Vadrot (2021) examine global collaboration networks, which show the dominance of the United States, European Union member states (namely Germany, France, UK), and Australia. They also provide data on the relationship between high output and high citations (Fig. 2.4), and while countries such as Brazil, India, China and Russia have high publication outputs, they have comparatively less citations. The Tolochko and Vadrot (2021) study considers only English language publications, and while the findings lead to numerous speculations as to why such patterns exist, the authors note that dominant countries have the highest 'collaboration capital' and thus influence on the global science system.

This is further more supported by Partelow et al. (2020a, b) at the country level, which presents findings indicating that the ratio of domestic to international collaborations (all publications classified as one or the other), is highly correlated with both the total number of collaborations a country has with other countries, and the number of specific countries a country collaborates with. More simply, if a country has a larger portion of domestic collaboration outputs (broadly indicating a stronger domestic science system such as in the UK, USA, Australia, Brazil, France, Germany, Mexico, China, India, Indonesia, Philippines, Kenya), it also has more total international collaborations and more specific collaboration partners. Countries with a larger portion of international collaboration outputs than domestic (perhaps indicating stronger dependence on external science systems), also have less total collaborations and less total specific countries with which they collaborate (e.g., small European countries, Chile, Cambodia, Argentina, Ghana, Pakistan). In tropical regions, the largest number of in-coming international collaborations are in Southeast and Southwest Asia as well as East Africa, with the fewest in West Africa,

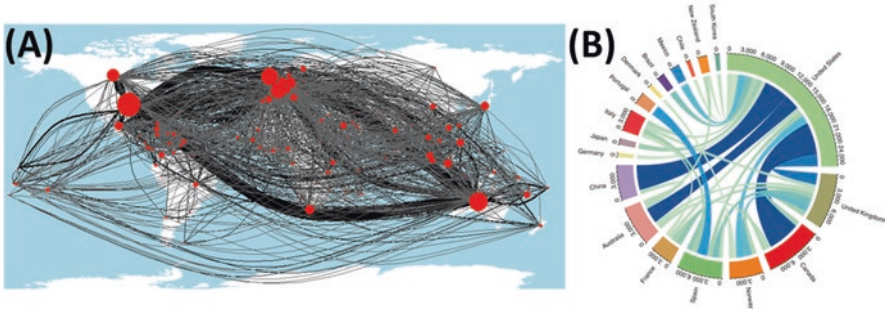

Fig. 2.5 (**a**) International co-authorship patterns between countries in the tropical marine science literature taken from Partelow et al. (2020a, b), with a dominant nexus between North America, European countries and Australia. (**b**) International co-authorship patterns between countries in global fisheries research taken from Syed et al. (2019), dominated by the US, Canada, European countries, Australia and China

indicating where international research partnerships exist (Fig. 2.5a). Globally, within tropical marine research, there is a Western-dominated nexus of science cooperation between Australia, North America and Europe (Partelow et al. 2020a, b). Syed et al. (2019), focused on global fisheries science networks, also show that the science powerhouses of USA, Canada, Japan, Australia, UK and Norway are now being joined by China, India, Mexico and Brazil. However, they also state that "as the field has become increasingly collaborative, historical links between European and North American countries have intensified" (p. 7), suggesting similar historical science cooperation dependencies (Fig. 2.5b).

Partelow et al. (2020a, b) also observe that the emergence of thematic areas or science agendas, indicated by clusters of terminology use over regions and time, are being driven by Australia, North America and Europe (as terminological anomalies i.e., new sets of words and phrases, emerge there first), later spreading to other world regions as part of a more mainstream discourse driven by Global North countries. This trend is supported in more specific fields such as within the 'ocean literacy' literature. Costa and Caldeira (2018) show that the concept of ocean literacy was started in the United States, and is currently dominated by publications from the United States, with other countries only beginning to adopt the term and publish on it years later. Back in the tropical marine science literature, Australian, North American and European countries lead the number of citations per publication per year with 5.8, 4.0 and 3.6 respectively, with all other regions below 3. Furthermore, Syed et al. (2019), in their global fisheries science analysis, find that North American and European countries publish in journals with higher impact factors and have higher rates of citations per paper. These findings are largely supported in a similar bibliometric analysis of global fisheries science literature, showing that there are no countries who have higher citation rates than the world average in the regions of South America, Africa or Asia except for China and South Korea (Aksnes and Browman 2016). Pauna et al. (2019) additionally show the dominance of the US, UK, Germany, France and Australia in marine microplastics research, with more

diverse groupings of transregional cooperation although all cooperation clusters of countries are dominated by the US or a European country.

In more specific studies on regions and thematic areas, disparities in scientific collaboration patterns and outputs are broadly similar with variations in each context. Kim et al. (2016), analyzing the marine biodiversity research literature, show that European countries, USA, Canada and Australia are the dominant co-authorship partners for China, Japan and South Korea. Mazaris et al. (2018) show the dominance of the UK and USA in sea turtle research, both in the number of international co-authorship collaborations and total outputs. However, they also note generally increasing collaboration globally, with the increased role of some countries in maintaining regional networks such as Croatia, Tunisia and Costa Rica. In contrast, although a rapidly growing collaboration hub, they highlight Southeast Asia as a sea turtle research cooperation gap. In the field of marine microplastics pollution research, Barboza and Gimenez (2015) provide findings showing an increase in domestic and international collaborative outputs globally, although dominated by Europe and the US, but also in Japan and numerous Southeast Asian countries.

In sum, current ocean literacy is primarily dominated by the values, leadership and outputs of Global North science systems, namely North America, Europe and Australia, although other large economies are starting to play a larger role such as Japan, China, Brazil and Mexico. Despite the exponentially increasing amount of published science on the ocean, what we know is not based on a complete empirical picture. Many spatial, disciplinary and thematic area gaps exist, and many domestic science systems are not yet developed to the extent to which they can become mutually beneficial eye-level cooperation partners within global and regional science cooperation networks.

2.4 Discussion of Theory and Ocean Governance Practice

2.4.1 Epistemic Inequalities Between Knowledge Systems

In order to discuss the above trends and implications on ocean science systems, we begin with an overview of how to frame the epistemic inequalities between knowledge systems. When we speak of ‘epistemic inequalities’, we mean focusing on those between knowledge systems, and the different types of knowledge systems or ways of knowing such as those between different world regions, between scientific disciplines as well as between genders and sexual orientations, ethnicities, and other possibly defining lines. These ‘epistemic inequalities’ (Wellmon and Piper 2017) rest on structural path dependencies related to the science systems in different countries (Morgan et al. 2018; Partelow et al. 2020a) and determine the possibilities and limitations available for governance in a globally coordinated, jointly devised manner. It is important to stress that none of these ‘knowledge systems’, whether commonly regarded as originating in or connected to a particular world region, discipline,

sex, age group or ethnicity, can be or is here regarded as a closed entity. Neither is any of them characterized by perceived homogeneity on the inside, or defined by clear-cut borders (thus representing container spaces). Instead, these knowledge systems are dynamic with porous borders, continuously (co-)evolving in and through the interaction, the exchange of ideas, ontological, and epistemological building blocks, and manifold forms of social, geographic, and epistemic mobilities (Mielke and Hornidge 2017a; Hornidge et al. 2020). Thus, rather than perceiving there to be variations and heterogeneity within one global knowledge system, these dynamics speak of different knowledge systems, which is further confirmed by existing hierarchical differences. Thus, knowledge systems are important to be assessed as units in their own right.

Not all knowledge systems are equally valued or even recognized, and thus a limited set of knowledge systems is more influential in shaping how and why scientific knowledge is created, and is utilized in decision-making, politics and governance. More simply, knowledge and power are closely intertwined. In the Foucauldian tradition, power and knowledge are understood to be inextricably related (Foucault 1980; Burchell et al. 1991). The nexus of power and knowledge can be productive as well as constraining: it can limit but also open new ways of acting and thinking. For example, the dominance of male Eurocentric understandings and practices of knowledge still affects patterns of knowledge systems such as which countries adopt and prioritize certain scientific disciplines, topics or governance approaches. In the ocean context, high nature dependencies, social inequalities and traditional/local knowledges have to be taken into account to analyse marine knowledge systems and power structures (Drew 2005; Martin et al. 2007). But many less adopted knowledge systems of traditional or Indigenous origin lack validation as useful and thus lack integration into decision-making forums that impact them directly. In the sense of everyday knowledge systems constructed in public-discourses at the interface of scientific, non-scientific, every day and traditional/local knowledges, analyses also need to consider political implications of marine knowledge systems including non-regarded and marginalized readings of the ocean (Cash et al. 2003; Ommer et al. 2012; Weichselgartner and Marandino 2012; Bennett 2016). They are shaped by given power structures and result in context-specific politics of knowledge.

In order to overcome existing asymmetries between knowledge systems that originated in unequal power structures and in turn constantly strengthen these power relations, marine knowledge systems need to be contextualized (Ommer et al. 2012; Weichselgartner and Marandino 2012). Still more research has to be conducted to further understand the unique characteristics, international logics, negotiation powers, and peculiarities of marine knowledge systems (Campbell et al. 2016; Blythe et al. 2021). Against this backdrop, a particular focus on marine ecosystem-dependent communities supports the assessment of existing hierarchies, and contestation thereof, of marine knowledge. Consequently, questions can be addressed of what the underlying rationales, logics, and power interests in different interpretation of marine realities are.

2.4.2 Epistemic Inequalities Between Scientific Disciplines

Within science, hierarchies between different types of scientific knowledge and structural processes of knowledge production are the result of the constant struggle for credibility and scientific authority via the search for the best argument or scientific findings. Outlining this struggle over epistemic authority, Gieryn assesses: "What science becomes, the borders and territories it assumes, the landmarks that give it meaning depend upon exigencies of the moment – who is struggling for credibility, what stakes are at risk, in front of which audiences, at what institutional arena?" (Gieryn 1999, x–xi). These struggles determine the defining boundaries of and hierarchies between basic versus applied sciences, between disciplines, but also, as empirically developed by Kohler (2002), between field and lab research. Based on a historical account of biological research, he argues: "Since the mid-nineteenth century, field biologists have lived in a world where lab disciplines have the greater credibility and authority, and they do still" (Kohler 2002, 307). Similar distinctions and structurally nurtured hierarchical differences can also be observed with regard to different disciplines. Especially scholarly work on the organisation of interdisciplinary research endeavours, bringing together natural and social sciences, empirically illustrates the need to overcome these hierarchies as precondition for cooperation at eye-level and interdisciplinary forms of knowledge production in its own right. Peter Mollinga (2008, 2010) for instance argues for the 'rational organisation of dissent' in interdisciplinary research settings as a crucial determinant for academic excellence without being apoliticised.

2.4.3 Epistemic Inequalities in Gendered Ocean Science

The patriarchal organization of the vast majority of societies practiced globally over centuries has resulted in gendered epistemes, in all aspects of social organization in which strong gender divisions in terms of exercising tasks prevailed. Gendered lenses in defining what is regarded as knowledge in and by society were the consequence (Doucet and Mauthner 2006). In connection with women's very late admittance to universities, also the breadth of women's academic achievements was largely truncated and only a selective list of women pioneers in their disciplines heralded. And while these forms of historically generated appropriations of women's knowledge are increasingly challenged, substantial shifts in male-dominated hierarchies in academia are statistically seen still outstanding (Fatnowna and Pickett 2002). Kristie Dotson, drawing on Miranda Fricker (1999), for instance, speaks of 'epistemic oppression' and points to "the persistent epistemic exclusion that hinders one's contribution to knowledge production" (Dotson 2014, 115). For developing her argument, she refers to postcolonial and gender-related contexts of exclusion, illustrating the interplay, but also succinct differences, between social, political, and

epistemic oppression as well as 'privilege'. Ian James Kidd, José Medina, and Gaile Pohlhaus take this further and have developed 'epistemic injustice' as a research category that integrates a variety of research topics and areas across major social and intellectual movements and fields, such as philosophy, feminism, hermeneutics, critical race theory, disability studies, and decolonising and queer epistemology studies (Fricker 2007; Kidd et al. 2017).

In response to this, in the 1980s, feminist interventions started developing feminist epistemologies and methodologies (e.g., Code 1981; Harding 1987; Haraway 1988; Lennon and Whitford 1994; Longino 1997; Fawcett and Hearn 2004; Doucet and Mauthner 2006). The authors built on the premise that women due to being socialized into particular gender-specific role patterns and social identities regard the world in many ways differently from their male counterparts. It was argued that through the development of feminist methodologies, female epistemologies could be empirically assessed and advanced in public, official, and academic discourses, while at the same time grappling with basic questions such as the nature of knowledge, epistemic agency, justification, and objectivity in general (Alcoff and Potter 1993; Doucet and Mauthner 2006).

Within the marine field, the gendered life worlds of marine-based societies, whether in the context of industrial and small-scale fisheries, or within the multifarious realities aboard ships and vessels, have been amply documented, particularly in terms of how sailing, surfing, maritime navigation, and other forms of seafaring have historically been perceived as distinctly "masculinized" practices (Mack 2011, 30; Laderman 2014). Yet these (interpretative) gendered essentialisms have also been critiqued across anthropological and transcultural scholarship spanning Oceania and the Mekong borderlands to Madagascar (cf. Astuti 1995; Probyn 2014; Gissi et al. 2018), which in turn illustrate the (internally diverse) livelihood practices, ontologies, and epistemologies of distinct sub-groups such as female pearl divers or Indigenous fisherwomen. However, in the context of scientific knowledge production, the gendered inequalities in marine epistemes come to be revealed in the relative (in)visibility of diverse stocks of knowledge about how marine life is perceived, experienced, and differently studied. Moreover, nascent scholarship in interdisciplinary fields such as Science and Technology Studies (STS) that explore epistemic cultures of knowledge production, particularly in the marine realm, often barely address the gendered nuances in science-oriented meaning-making (cf. Helmreich 2009), while conceptual strands such as feminist and postcolonial STS have conventionally dealt with questions that have largely been driven by terrestrially-oriented disciplines (e.g., botany, forensic science, clinical research), often produced in firmly 'grounded' spaces such as chemical laboratories, engineering, and medical institutes (cf. Harding 2011; Subramaniam 2014). Thus the gendered epistemic dynamics inherent in the liminal floating worlds of knowledge production (for example on submarines and research vessels) are only but beginning to be explored across the marine humanities and the social sciences.

2.4.4 *Transregional Networks of Knowing & Governing*

Knowledge production with regard to the world ocean is – as all knowledge production on global commons – shaped by the transregional networks driving it and thus by the interests, values, logics and (legal, financial) structures shaping these. As such, the above outlined scientometric analysis on peer-reviewed journal articles in the field of tropical marine sciences identified a set of material and immaterial path dependencies co-shaping how we know the systems of tropical coastal waters (Partelow et al. 2020a, b). Material path dependencies include equipment, labs, and access to research vessels and marine research stations. Immaterial path dependencies include access to funding and donor landscapes, language of research and teaching, science networks and discipline. These link with larger discussions by postcolonial scholars on historically grown knowledge hierarchies (emerging out of the Enlightenment period of Europe) between normatized standard European and neglected non-European knowledge systems. As such, Gloria Emeagwali (2006), Dipesh Chakrabarty (2000), and other scholars have pointed to the 'intellectual dominance' of the West as being legitimized by way of colonial histories, which have resulted in presumably 'destined' trajectories that re-ordered the world and 'naturalized' cultural hierarchies, and of thus 'grown' all-encompassing epistemologies rooted in the Greco-Roman worlds. Gayatri Spivak criticizes that Enlightenment humanism did not include non-European cultures in its understanding of 'man', who was rather understood as the "settler-colonial white man" (Spivak 1999, 26). Chakrabarty, with his concept of 'provincializing Europe' (Chakrabarty 2000), seeks to unveil the constructed nature of universalist assumptions and to engage Western and non-Western histories and knowledges in equilibrious negotiation in order to "displace a hyperreal Europe from the center" (p. 45). Walter Mignolo connects the "coloniality of power (economic and political)" with the "coloniality of knowledge and of being (gender, sexuality, subjectivity and knowledge)" as entangled characteristics of modern society that constantly reproduce "coloniality" and calls for a 'pluriversality' of knowledge production (2007, 450–53, 2012, 49, 51–60). These ideas are further taken up by scholars such as Linda Tuhiwai Smith (1999), Margaret Kovach (2010), and Gurminder K. Bhambra (2010), who make clear that prioritized Western-based research practices and policies reproduce colonial relationships in the academy and that the epistemological challenge is to achieve a "systemic shift in the ideology of knowledge production" (Kovach 2010, 28; cf. Knopf 2018a, b).

More recent debates in Area Studies (Mielke and Hornidge 2017a, b; Derichs 2017; Middell 2013; Jackson 2017) bring these postcolonial assessments together with increasing geographic, social, and epistemic mobilities, and thus with questions on how the travel of goods, people, ideas, capital, lifestyles, and symbols render perspectives on the world as divided into particular world regions, each defined by a set of cultural characteristics and languages on the inside and different ones on the outside (i.e., defining regions as 'container spaces'). Instead, de-territorial perspectives on how social realities are being negotiated are being discussed

(Hornidge et al. 2020). Here, the ocean is also gaining attention as a transregional water body and global common that challenges and offers substantial opportunity for joint understanding and governing (Mielke and Hornidge 2017b; Alff and Hornidge 2019; Tessnow-von Wysocki and Vadrot 2020).

2.5 Final Remarks: Regimes of Knowing for a World Beyond 2030

Knowing the world ocean is necessary for living with global challenges. Yet, knowing it requires pluriversality, and thus transregional dialogue processes that are structured by reduced hierarchies that allow mutually understanding and learning. Recognizing the many different ways of knowing, and valuing the contributions and different epistemic views and knowledges is essential for social justice and inclusion, and also for the progression of science and governance. As the focus on ocean matures into twenty-first century development discourses, policies and governance practices, enabling the transition towards more equal epistemic ways of knowing and doing will require re-shaping the structures of knowledge production. This will entail large, self-reflective and proactive efforts to materialize, where the processes of recognition and actions towards change themselves will play a large role in manifesting new integrated knowledge landscapes premised on pluralism. Building on the introduction to this book, and as we will see in the forthcoming chapters, ocean governance for sustainability requires knowing the ocean, and how and why we know the ocean in part to be a reflection of the science-policy interfaces and knowledge governance practices that enable and constrain its diversity, integration and uptake. This chapter has provided an overview of some of the theoretical foundations with which the chapters in this book can be reflected upon. In many ways, the book is about the nexus of knowledge and governance – a nexus shaping society's path towards sustainability.

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