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Five social science intervention areas for ocean sustainability initiatives

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Ocean sustainability initiatives – in research, policy, management and development – will be more effective in delivering comprehensive benefits when they proactively engage with, invest in and use social knowledge. We synthesize five intervention areas for social engagement and collaboration with marine social scientists, and in doing so we appeal to all ocean science disciplines and non-academics working in ocean initiatives in industry, government, funding agencies and civil society. The five social intervention areas are: (1) Using ethics to guide decision-making, (2) Improving governance, (3) Aligning human behavior with goals and values, (4) Addressing impacts on people, and (5) Building transdisciplinary partnerships and co-producing sustainability transformation pathways. These focal areas can guide the four phases of most ocean sustainability initiatives (Intention, Design, Implementation, Evaluation) to improve social benefits and avoid harm. Early integration of social knowledge from the five areas during intention setting and design phases offers the deepest potential for delivering benefits. Later stage collaborations can leverage opportunities in existing projects to reflect and learn while improving impact assessments, transparency and reporting for future activities.

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INTRODUCTION

Positive social impacts and benefits are not self-evident or inevitable features of ocean sustainability initiatives. Making ocean sustainability initiatives more effective requires meaningfully integrating social and natural sciences[1–6]. We use the term 'initiatives' to refer broadly to specific undertakings or projects related to concrete actions in the realms of ocean policy and governance, economic development, conservation and management practice, ocean research or funding programs. Each initiative has a knowledge base that informs its agenda and actions, and will tend to have four phases: (a) intention setting, (b) design, (c) implementation and (d) evaluation[7]. To date, many ocean sustainability initiatives have primarily focused on the biophysical dimensions of ocean sustainability (e.g., larval connectivity in marine reserves, incorporating representative habitats, ensuring fisheries yields are biologically sustainable)[8–10]. Less than 5% of all ocean science literature is social science (Fig. 1A), understood here

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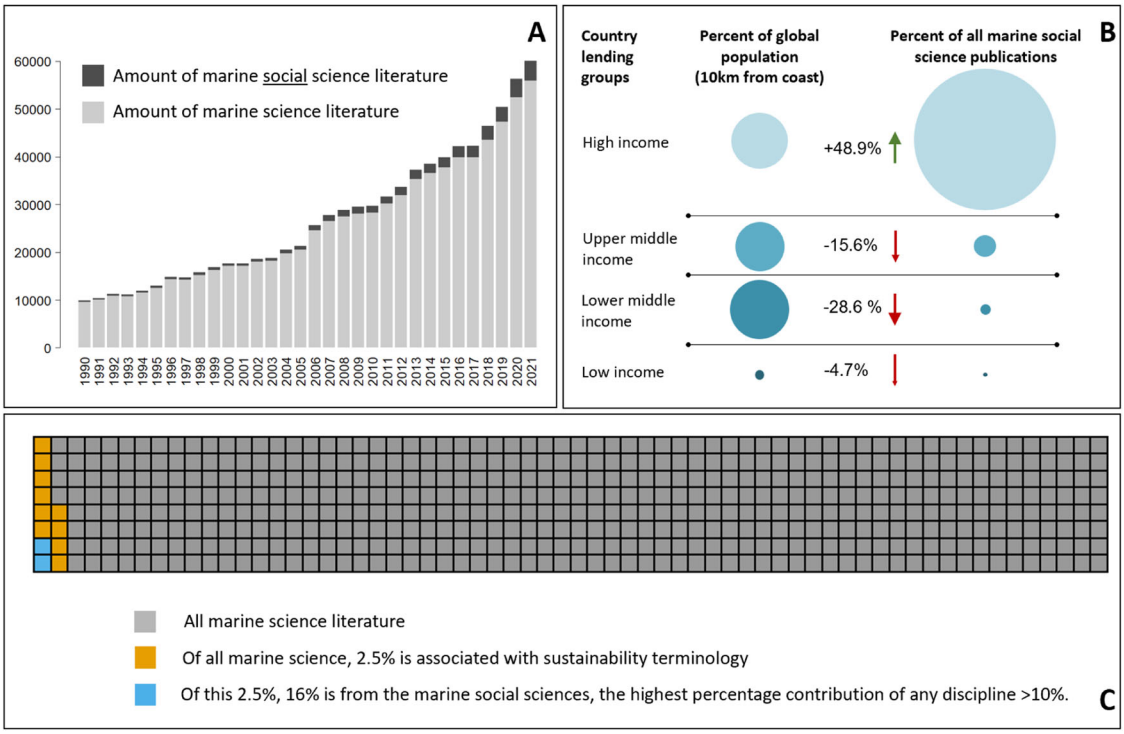

Fig. 1 Trends in marine social science. A Amount of all marine science and marine social science literature (*y*-axis) over time (*x*-axis). Social science* contributed 3.4% of marine science literature in 1990, and 7.4% in 2021. **B** Country lending groups from the World Bank by the percentage of coastal population compared to the percentage of marine social science literature from researchers in that lending group. **C** Marine social science sustainability contributions to the marine science literature in visual percentages. All data from SCOPUS on November 10, 2022 with the search string ((TITLE-ABS-KEY(ocean OR marine OR sea))), adding (AND sustainab*) for sustainability focus literature. Coastal population data from Neuman et al., (2015). *SCOPUS has its own 'social science' classification and we added economics, business management and psychology in addition.

as all disciplines and fields studying social phenomena, activities, practices and attributes (see[11] for a review).

Here, we focus on how ocean science initiatives could better engage with the marine social sciences – understood here as a diverse and interdisciplinary (defined by[12]) branch of the social sciences that embraces quantitative and qualitative methods to provide multiple empirical and conceptual lenses through which the relations between humans and the ocean can be understood[4]. Ocean sustainability initiatives operate in different contexts than similar initiatives on land, and knowledge cannot always be directly transferred[13]. Ocean social-ecological systems have unique characteristics that can make building social knowledge and social engagement more challenging[14,15]. For example, fishers have unique psychocultural adaptations and risk profiles, which affect how they view and respond to policies[16,17]. Coasts are fluid boundary areas that are often multi-use, common-pool, interdependent across large distances, highly biodiverse and embedded in long histories of cultural meaning, value and political contention[15,18]. They face the triple squeeze of climate change, rapid economic development and expanding area-based conservation efforts[19], and conflicting human uses can also occur between recreation, conservation, cultural values and economic interests. Environmental conditions can change rapidly, with different spatial and temporal dynamics than land-based systems, requiring institutional changes and governance adaptations that fit context rather than repeating what has worked because it is intuitive, familiar or fits existing governance norms or administrative structures[20,21].

Marine social science research makes substantial contributions to both fundamentally understanding sustainability problems and informing their applied solutions. The field of marine social science produces an outsized proportion (16%) of the knowledge associated with ocean sustainability terminology compared to other scientific disciplines (Fig. 1C). A core part of this knowledge is a diversity of topical insights and analytical tools - both quantitative and qualitative, fundamental and applied - which can be leveraged within ocean sustainability initiatives[14,22–26]. Diverse collaboration potential exists to utilize these tools, in both science and practice, to increase the likelihood of positive social impacts while helping to avoid harms, setbacks and capacity burdens[11,27,28].

Benefits to ocean sustainability initiatives from the use and integration of the marine social sciences have been well documented. For example, Marine Protected Areas (MPAs) can improve conservation goals when they are designed to consider the degree and location of human pressures around them[29]. Meeting pluralistic goals of ocean conservation is, for example, often made possible when differentiated rights, social uses, perceptions and impacts are considered and integrated into management[30–32] and funding agendas reflect local priorities and knowledge[33]. This can include local history of use and traditional stewardship practices that legitimize the value of local, traditional or Indigenous knowledge[34]. The opposite is also true – marine conservation initiatives can fail due to "mistaken assumptions that offshore spaces are unpeopled"[35]. Likewise, Marine Spatial Planning (MSP) and fisheries management can be more effective when rights and tenure, stakeholder inclusion and valuing diverse knowledge systems are prioritized[36]. Furthermore, bringing ocean industry partners together to align goals, self-govern and create joint impact can set the example and shape the agenda for tangential industries and non-participant actors in the same industry to shift activities and adopt best practices[37]. Voluntary commitments to ocean sustainability have emerged from some of the most impactful and largest ocean industries (i.e., offshore oil

and gas, marine construction, seafood, shipping, cruises) and exist in the form of 'green clubs'[38]. For example, the Zero Emission Maritime Buyers Alliance has been formed to decarbonize the shipping industry, a partnership between The Aspen Institute, Amazon, Patagonia, and Tchibo. Also, the SeaBOS project created science-industry partnerships with the largest seafood companies to develop a coalition of commitments for ocean stewardship over years of inclusive dialog[37]. However, they need rapid innovation, science partnerships and public policy support to scale impact with sweeping reforms[38]. The above approaches can help address power imbalances – political, economic and epistemic – by building trust and legitimacy through enhanced communication and deliberation[39–43]. Knowledge co-production practices are emerging as an effective mechanism to address power and tradeoffs, and can make initiatives more inclusive and fit to local contexts[25]. For example, aligning offshore energy and aquaculture zones[44] or for addressing ocean acidification[45].

Furthermore, ocean sustainability initiatives that consider key social science intervention areas are more likely to reduce or avoid harms and associated costs while delivering comprehensive benefits[46]. There is a need to move beyond unexamined assumptions and generalizations about people and social systems, and towards context specific, science-based and informed decision-making that have reflexive practices and acknowledge positionality[47,48]. Collaborating with marine social scientists from the onset of initiatives is where the most gains can be leveraged. Without such collaborations, initiative success is less likely, even if goals are ecosystem or biologically focused. In this context, it is clear that ambitious progress towards Sustainable Development Goal 14 'Life Below Water' can avoid costly setbacks and harms when informed by social science[49]. Arguments for such an agenda are now growing and diverse[2–4,50–56]. Transdisciplinary practices are gaining attention[5,57–61]. Engaging local communities who will be impacted is essential[54]. A popular approach is co-management, and increasingly adaptive co-management, which is more aligned but needs to be coupled with just participation, empowerment and trust-building through knowledge co-production with clear goals[60,62,63]. This is also true for global scale geopolitical issues where there are clear inequities in agenda setting power, economic leverage and access to resources[64]. Importantly, the above literature and arguments build on the broader environmental and conservation social science literature which has laid essential foundations[65–68].

New ocean sustainability initiatives are currently underway in all corners of the globe. However, much of the marine science research to date comes from high-income countries (Fig. 1B). Blue and Circular Economy agendas are being pushed forward by the United Nations, World Bank, European Union and transregional partnerships in Europe, Asia and Africa[69]. Other major initiatives include efforts to protect 30% of the ocean by 2030, along with the United Nations agreement for protecting Biodiversity Beyond National Jurisdiction[70,71]). More national-to-regional initiatives are emerging such as the Boe Declaration for Regional Security among Pacific Island nations, the Caribbean Regional Oceanscape Project (CROP) and the Nairobi Convention for ocean governance in the West Indian Ocean. Furthermore, activities within the UN Ocean Decade are supporting a wide variety of projects in ocean contexts (https://oceandecade.org/). In tangent, funding for marine conservation is growing rapidly (https://oursharedseas.com/funding/)[72]. In order to deliver the benefits envisioned in the above initiatives, there is a need to invest in capacities for creating and using social knowledge (i.e., budget, time, willingness and trust)[73]. Intervening in the early phases of intention setting and design can help ensure that such investments are well considered, just and equitable[74–76].

As a group of diverse inter- and trans-disciplinary marine social scientists, the authors of this paper feel well-situated to reflect on and synthesize five intervention areas outlined below: (1) Using ethics to guide decision-making, (2) Improving governance, (3) Aligning human behavior with goals and values, (4) Addressing impacts on people, and (5) Building transdisciplinary partnerships and co-producing sustainability transformation pathways. However, we acknowledge that this perspective is exploratory in nature, and that our positionality as a group may be a limited one. Most of us are located in universities in the so-called Global North. Although many of us have extensive experience exploring and implementing the intervention areas below around the world, future research is required to understand broader perspectives and recommendations for how they will need to be adapted and contextualized across contexts.

FIVE SOCIAL SCIENCE INTERVENTION AREAS FOR OCEAN SUSTAINABILITY

We detail five social science interventions areas that can - when invested in and utilized - help deliver the comprehensive benefits expected from ocean sustainability initiatives. Each offers an entry point into a different problem area that the marine social science community advocates as an essential consideration. In each area, the marine social sciences have a wide variety of tools and capacities for building knowledge. Each intervention area can inform the four phases of an initiative: (1) intention, (2) design, (3) implementation, and (4) evaluation (Fig. 2). Those four phases reflect what is often characterized as 'transformative research'[77]. Effective collaboration with marine social scientists at each phase can improve the likelihood of cumulative effectiveness across and beyond the initiative's lifespan. Nonetheless, integrating social knowledge early (i.e., during Intention and Design) offers the deepest potential for improving benefits and avoiding harms[78]. Later stage collaborations offer much needed potential to leverage opportunities in existing projects that can reflect on learning, improve impact assessments, increase transparency and reporting while offering feedback for early integration into future activities. For each intervention area below, we outline the basic definitions and factors to consider from the recent literature to guide deeper inquiry. For each intervention area below, we first review the foundational theory and then detail concrete applications.

Area 1: Using ethics to guide decision-making

Ethics are an ever-present feature of social systems. They are implicit in our economic and governance models, but also explicitly guided in the Universal Declaration of Human Rights or the UN Agenda 2030. Ethical norms are also embedded features of diverse local cultures and onto-epistemic communities of science and practice, where research and initiatives need to put more effort into aligning with them, as exemplified in the Kulana Noi'i research protocols in Hawaii (https://seagrant.soest.hawaii.edu/kulana-noii/). However, it is not always clear what the right thing to do is or how to make the best, most appropriate or locally aligned decisions. This is especially challenging because ethics, values and norms are likely to vary and involve tradeoffs within and between initiatives in different contextual settings. Core questions are: Which normative worldviews, ontologies and epistemologies are prioritized to shape decisions? How can we better recognize and reflect on the ethical choices and implications of initiatives in different contexts and partner constellations? How are future generations taken into account? How could ocean science contribute to 'planetary justice'[79]? More broadly, how can ocean science assure that despite geopolitical differences, we will be able to work together as a global community to build an agenda for sustainable development beyond 2030? As such, ethics resonate through all the social interventions areas. Important ethical considerations such as justice, equality, gender or inclusion, for example, are

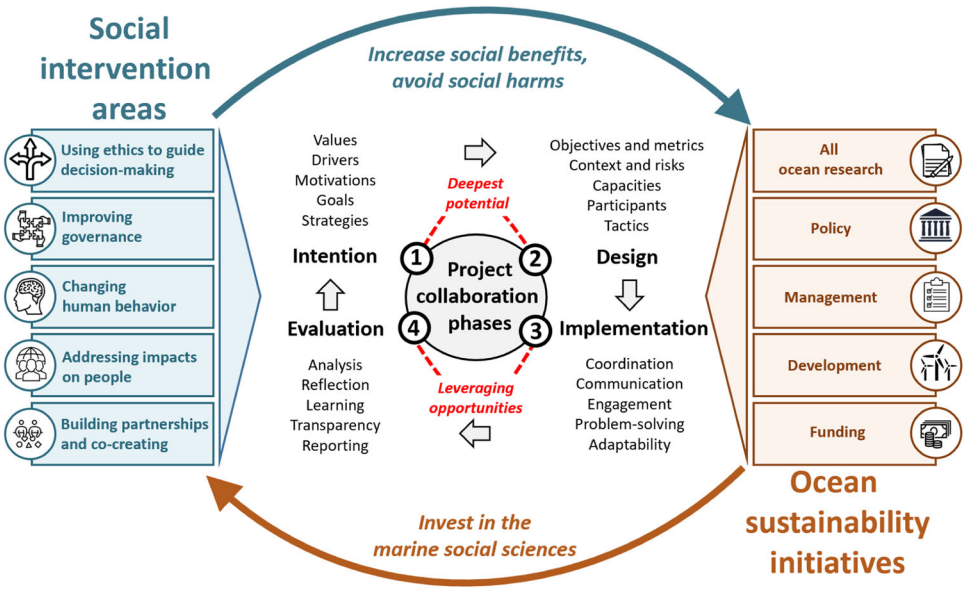

Fig. 2 Social intervention areas in ocean sustainability initiatives. Working with the social intervention areas (left) can increase the social benefits and help avoid the harms of ocean sustainability initiatives (right). There are four phases of project collaboration where working with the social intervention areas can improve the likelihood of benefits: (1) Intention, (2) Design, (3) Implementation, and (4) Evaluation. Early social area integration into projects (i.e., Intention, Design) offers the deepest potential for more benefits. Leveraging opportunities at later project stages (i.e., Implementation, Evaluation) offers important reflection, learning and testing of collaborative engagement.

gaining traction as guiding concepts for governance and development in the marine realm[74,80], which are reflected in important global development ambitions such as the Sustainable Development Goals (https://sdgs.un.org/goals). Empowerment is another often championed virtue of policy and intervention projects[81–83], but must first follow a do no harm principle. For every ocean sustainability initiative, however, the ethical issues at stake are likely to differ, which suggests that deliberation over ethics should guide the setting of intentions, design, implementation and evaluation of projects based on context-specific needs and capacities.

Ethics can be interpreted differently across different initiative phases. Knowledge of ethical theories can help better align intentions, design and implementation with desired benefits and outcomes. For example, utilitarian or consequentialist perspectives argue that the right choice is the one that maximizes benefits for the most people. Trade-offs may arise, such as between the ecological conservation versus use of the area for local livelihoods[84,85], or public access rights to the coast versus private development and whether access rights are equal across demographic groups[86]. In contrast, deontological ethics offer more prescriptive rule-based guidance on what is ethical, not focused on an outcome but rather relying on legal or normative cultural or religious institutions (e.g., human rights, religious doctrines). The ethics of social contractualism offer yet another perspective, where the right approach is to find agreement among participants rather than maximize outcome or be guided by external rules. Social contractualism is emerging in voluntary agreements, co-management arrangements, green clubs and partnerships[38,87–89]. However, agreement can be difficult, often with high coordination and communication costs for collective action[90], but voluntary and co-management agreements are often put forward despite challenges but can be more successful when inclusive and participatory[91]. Virtue ethics, another pillar of ethical theory, posits that an individual will do the right thing at the right time[92]. What are the virtues of different actors in ocean spaces, will these lead to the ocean we want, and can we empower virtuous behavior? There are many virtuous actors, but do they have scalable impact and power? The legitimacy of each ethical theory can be argued and justified as the right approach in different contexts – but acceptance of moral equivalence is not enough. Many projects set clear normative goals or are guided by sign-posted sustainability agendas, but normative notions of sustainability differ between interest groups[93]. As such, certain ethical approaches may offer clear advantages and more desirable outcomes. The easiest ethical path or the path most aligned with the interests of those with decision-making power cannot be the criteria for choosing. For example, Western ethical traditions (including those mentioned above) rarely account for the depth of human-nature relations and epistemic differences of those relations, which can lead to conflicting worldviews with, for example, indigenous communities or diverse local cultures around the world[94] in relation to the ethics of stakeholder engagement. Thus, ocean sustainability efforts may require us to expand our notion of what constitutes 'right' and 'good' based on a grounded understanding of local ethics[95,96].

Area 2: Improving governance

Governance refers to a suite of policy mechanisms, social processes and organizational structures for making decisions and guiding the behavior, actions and activities of society[14,97,98]. Improving governance for ocean sustainability initiatives involves understanding, designing and implementing those mechanisms, processes, institutions and structures to meet our normative sustainability goals. Environmental governance has a rich literature of examining multi-level, multi-scale and polycentric collaborative arrangements and the different roles of governments, self-organized communities, the private sector and societal stakeholders within them[90,98–101]. A central premise for improving governance is collective action - finding ways to work together effectively to co-create goals and develop mechanisms and structures to enable their actualization by those involved[102]. However, the lack of coordination and communication have led to fragmented ocean governance approaches[103,104]. Nonetheless, momentum is building for procedural justice approaches such as inclusion, participation, transparency and democratic decision-making[97]. Another challenge is ensuring that governance

approaches fit the problem and context they aim to address[105]. Adequate social knowledge of existing governance mechanisms and organizational structures, such as knowledge of who is involved, who may be affected and what capacities exist for realization can inform the design of contextually appropriate governance systems. Furthermore, a recurring challenge for governance is that innovation and actions often outpace the ability of governance institutions to respond. Acknowledging this challenge, suggests there is a need to understand what features of fisheries management, local marine stewardship, marine conservation, and other ocean related initiatives will enable rapid adaptation and innovation for improving sustainability in different contexts. Investments into improving governance – based on an understanding of lessons learned and best practices - are needed while working together with regulators and stakeholders to build robust governance institutions.

For ocean sustainability initiatives, understanding the landscape of governance within which the initiative operates, as well as the role of the initiative as a governance actor itself, is essential for improving the likelihood of social and environmental benefits. Many initiatives fail to achieve impact due to poorly designed rules, norms and procedures, or the lack of considerations for how the beyond-project institutional landscape will shape within-project dynamics and outcomes. An understanding of the involved actors, rules and social norms that surround project implementation is an important foundation for deciding what investments should be prioritized or where international aid or national budgets should be directed towards[72,106,107]. Furthermore, ocean management policy without concomitant long-term financial investment is less likely to be successful. For example, MPAs without adequate financial planning or accounting can fall short of intended goals[108]. On the other hand, leveraging novel and co-beneficial financing strategies such as tourism fees for marine parks can leverage the willingness of travelers to pay while providing local organizations the financial ability to realize everyday activities such as monitoring, restoration or waste management[109,110], although tourist dependent funding may be uncertain during low seasons or disaster periods (e.g., COVID-19), undermining long-term efforts[111]. The mainstreaming of co-management locally is an often-championed step in the right direction for inclusive and participatory governance. However, without sufficient facilitation, leadership, community buy-in or capacities for dealing with diverse stakeholders' preferences and needs - or consideration of the political-institutional context (i.e., it may be uncomfortable or unfamiliar to voice concerns in formal settings), co-management can fail to deliver comprehensive benefits. At higher levels, the translation of international and national agendas down to the localities where they are implemented is a perennial challenge laden with power, politics and bureaucracy[112]. Issues such as who and how such agendas were created, the capacities given to enable them, and how they are enforced, are regular themes in climate adaptation and mitigation initiatives (see, for example[113,114]). Steering political economies with the right regulatory and legal incentives to provide social benefits and avoid harms by, for example, conducting social impact assessments, can help reduce the created vulnerabilities from those systems to issues like coastal climate change impacts[114] or the globalization of seafood markets[115]. Social sciences can also help to understand how this 'steering' could be implemented given different lobby groups with individual political agendas.

The ocean also offers opportunities to contribute to climate change mitigation through pro-active initiatives in renewable energy, fisheries, transport, ecosystem regeneration and seabed stewardship[116]. The ability of such initiatives to contribute positively is highly dependent on governing them effectively, which requires a baseline knowledge of their social problems and realistic institutional capacities to steer change. For example, the rise of aquaculture comes with hope for reducing capture fisheries pressure while delivering the health and economic benefits of seafood trade[117,118]. However, without governance that considers how aquaculture will affect social, cultural and administrative interdependencies with capture fisheries, agriculture and different trophic carrying capacities and levels in the sea – alongside property rights, pollution and invasive species issues - delivering positive benefits will be fragmented and challenging[119–121]. Methods for cost-benefit analysis need to be extended towards risk-opportunity analyses in order to account for non-market values, potentialcumulative gains, and livelihood implications[122,123]. Overall, baseline knowledge of how local governance systems function needs to be paired with political ambitions, where ocean sustainability initiatives often need to balance ambition with practical barriers and local realities.

Area 3: Aligning human behavior with sustainability values and goals

Understanding how to effectively and ethically change human behavior is essential for many sustainability initiatives[56,124–127]. Behavioral research and interventions are well established in the environmental governance literature, but less so in marine contexts[56]. Understanding what drives behavior and how intentions and actions are shaped by context is crucial for designing effective interventions[125,127]. What will work, however, is not always intuitive. Perverse outcomes can arise when initiatives 'crowd out' pro-environmental behaviors[128,129]. For example, payments for ecosystems services schemes that allocate payments in a way that prioritizes autonomous intrinsic motivation were 6.3 times more likely to improve pro-social and environmental behavior (i.e., crowd-in) than schemes that do not, for example, those that only provide labor payments with a need to work together as a group[128]. Pro-environmental behaviors are decisions, choices, actions, and habits with respect to ocean related issues[130] and they can be categorized into: (i) private-sphere actions (e.g., purchase, use and disposal of products that do not harm the ocean during production or after disposal) and (ii) public-sphere actions (e.g., active involvement in community or public policy)[131].

Effective interventions have shown that there is a need to move beyond simplistic models of people as self-interested or rational[47], and towards pluralistic understandings based on institutional and social-ecological context[132,133]. A large and diverse literature has shown that individual and community actions are guided by rules (e.g., gear restrictions, participation mandates, sanctioning), norms (e.g., religious practices, gender roles, honor, trust) and social networks (e.g., power, influence, information sharing, learning and social institutions)[134–136]. These factors create a dynamic cognitive landscape of values, beliefs, attitudes, biases and intentions that will vary by location. Accordingly, practical behavioral intervention tools considering these factors have been researched and succinctly described for practitioners within sustainability initiatives[125,137,138], as well as for ocean educators[127].

Evidence suggests that behavioral interventions are more likely to be successful when audiences are well defined, benefits and barriers to behaviors are clearly identified, and key motivators and cognitive biases are known[126,139]. For example, messaging campaigns to nudge the reduction of plastic bag use will vary in effectiveness across context and cultures if the message is positively (e.g., you can help!) or negatively framed (e.g., polluting kills!), or if the messaging comes from a trusted person or organization locally (i.e., community leader, company or government)[140,141]. Similarly, choice architecture can guide non-invasive behavioral changes that benefit people and nature. For example, labeling sustainably caught seafood options, providing brief descriptions of health or environmental benefits on packaging or menus, or listing more sustainable food options at the top of a

menu can make more sustainable choices more appealing at a low cost and without perceived coercion[142]. Another critically important factor shaping behavior is social dynamics within social networks[90]. Within groups of fishers, for example, the social configurations of who works with whom, how information is shared and the embedded power dynamics between individuals with different assets and influence have been linked to the variation of individual capacities to adapt to climate change or proactively take transformative actions that improve social and environmental outcomes[143–145]. Recent work has also highlighted the role of emotions, which are thought to play an important part in ocean-related behaviors and for understanding the relationship between people and the marine environment[4,146]. Evidence suggests that emotional connection, including empathy, fear, enthusiasm, etc., has a central role to play in driving behavior change[147]. Behavior is, importantly, also shaped by higher level institutions, policies and politics. For example, changing the behavior of fishers or tourism operators may first involve the need for changing the discourse or information landscape guiding local politicians, community leaders, value chain actors or political groups[46,148]. Furthermore, the burden of behavioral change cannot be solely placed on individuals. Responsibility for creating the right incentive mechanisms and regulatory frameworks lies with governments, preferably through participatory and co-management approaches, along with industry and funders. In this context, it is important that incentives and regulations go beyond their current narrow focus on 'enabling' people to make transformative changes but also look at what affects people's 'willingness' to do so[149].

Area 4: Addressing impacts on people

A key message in Area 4 is the need to create initiatives that can deliver socially distributed benefits, which means first recognizing social differences and understanding vulnerabilities in order to create mechanisms that can proactively address them and avoid harm. Ocean sustainability initiatives are very likely to affect people and communities differently based on their geographical location (e.g., rural/urban; Global North/South), culture, occupation, history, gender, age, race, nationality, ethnicity, sexual orientation or socio-economic backgrounds (e.g., education, income, job security)[18,150–152]. These factors will influence how social groups behave, use resources, form and enact values, interpret the past, imagine futures, face inequality or marginalization (i.e., due to privilege and oppression), or deal with social power issues. Recognizing and analyzing the multiple axes of social differentiation is commonly referred to as intersectionality.

Recognizing differentiated impacts is a first step towards adapting initiatives at each phase (Fig. 2) to ensure that benefits or harms are not disproportionately impacting some groups more than others. Delivering such multi-dimensional benefits is now a central expectation of many initiatives and funders[153]. Creating environmental, social and governance impact is, according to a recent survey, the number one motivation for Blue Economy investors in the European Union, who are expected to create a 2.54 trillion Euro Blue Economy by 2030[154]. Using the appropriate methodologies early in an initiative is critical for building social knowledge that recognizes and accounts for the many axes of social differentiation across our diverse ocean-engaged and dependent societies today and in the future.

Intersectional analyses are essential for understanding differentiated social impacts. For example, how seafood value chain changes affect women differently[152,155], or how marine park management can fail to account for diverse resource use and stewardship practices by indigenous or minority communities[156], or how exposure to environmental hazards is likely to compound negative impacts for already economically and politically marginalized groups[157]. Furthermore, for future generations, Social Impact Assessments are not yet a well adopted practice for ocean initiatives, but can play a substantial role in guiding best practices when done effectively by marine social scientists[158]. This is important because many ocean sustainability initiatives have gained substantial traction despite their lack of social considerations, which can have exclusion or marginalization impacts for social groups. For example, Marine Stewardship Council certification offers livelihood benefits in the form of exclusive market access, stability and price premiums to certified fisheries, but certification has high financial and administrative costs which excludes the participation of many small-scale fisheries with high potential for sustainability for which standardized assessment protocols and value chain consistency requirements do not fit the contexts in which they operate[159]. Similarly, large port development projects such as in Southern California may provide economic and political green growth opportunities for local elites and regional economies, but fail to address how they reinforce racial and class divides among groups facing the health consequences of pollution impacts and labor injustices[160]. Indeed, such research ought to be combined with advancing other tools such as regulatory impact assessments and ocean accounting. Ideally, shared efforts support scenario development in favor of the diversity of people, their livelihoods and relationships to the sea.

Area 5: Building transdisciplinary partnerships and co-producing sustainability transformation pathways

Building partnerships is about working together, recognizing and addressing shared risk, and charting pathways towards a shared future. Knowledge co-production (or "co-creation") is an essential foundation for effective collective action[63,161,162], and becoming a central practice in inter- and trans-disciplinary ocean science[5,57,58,60,163]. Much can be learnt here from decades-long experiences in fishers' knowledge research and associated collaborative research partnerships[164–166]. The legitimacy and credibility of how knowledge is produced, valued and used to inform ocean activities can be strengthened when it is pursued together[25] and with care[167,168]. Importantly, different ways of knowing (e.g., indigenous, cultural or experiential knowledge) can provide new insights, partly because the world can be seen through different viewpoints, and partly because different methodologies are applied with different ways of knowing. Co-production processes have been shown to widen what we know and how we know it, as well as strengthen relationships among co-creators and the practical uptake of knowledge[162,169].

Ocean industry partnerships can enable more communication and transparency while creating dialogue to develop best practices based on science that can lead to industry-wide advantages that benefit nature[37]. Collaborative environmental governance arrangements offer opportunities for shifting relationships between government, science, industry and society – in ways that can balance power, inclusion and democratic participation[90,170–172]. A review of 165 regional ocean governance arrangements suggests that there is substantial opportunity to strengthen polycentric connectivity to improve coordinated decision-making, and there is opportunity for regional partnerships to more effectively link national policies with global level agendas[103,104]. In science, co-creation partnerships can include interdisciplinary interactions as well as transdisciplinary non-academic partnerships with a wide variety of different societal actors. However, co-production in itself is not a panacea, it requires careful reflection on its appropriate use, consideration of unanticipated consequences and involvement of skilled individuals and organizations with expertise in building and strengthening interactions between researchers and stakeholders that connects science, policy, practice and community[161,167,173]. For example, transdisciplinary knowledge co-production can more

effectively create useable knowledge to guide ocean investment projects because those who will use it – when they are part of the process - have shown to be more likely to trust its validity and have stake in its uptake[58]. Similarly, including local, indigenous or experiential knowledge of communities and practitioners with years of experience in observing and dealing local problems has high potential for aligning project phases to local needs, compensating for scientific methods which struggle with capturing local complexity, power dynamics and cultural issues[111]. Co-production can also increase the potential for legitimacy and stakeholder buy-in locally when, for example, leaders of those stakeholder groups are part of the co-production processes. Co-production can be supported by other knowledge exchange mechanisms, including the use of policy intermediaries such as knowledge brokers or boundary organizations[161,167,173,174]. In sum, the social sciences offer a comprehensive toolkit of methodologies for evaluating and guiding knowledge co-creation processes and building partnerships that emerged in different fields such as participatory research, mode 2 science, civic science, post-normal science, transdisciplinary and joint knowledge production, futuring, action research, translational ecology or engaged scholarship[25,63,175].

RECOMMENDATIONS FOR IMPLEMENTATION

Evidence-based and informed decision-making is an international best practice that we should strive towards in the pursuit of a sustainable ocean[48]. Yet, this remains challenging in practice. For example, a study of 1664 ocean economy businesses indicated that only 26% of them are aware of the negative sustainability impacts they create, and are doing something about them[176]. According to the Global Ocean Science Report[48], less than half (~40%) of the surveyed National Oceanographic Data Centers around the world collect socio-economic data, whereas all other data categories (i.e., geophysical, biological, chemical, fisheries) are each collected by well over 75% of the Centers[48]. Here, we make actionable recommendations - a set of practices - that can support the five social intervention areas:

1. Invest in the marine social science across all initiative phases.
2. Strengthen knowledge co-production.
3. Leverage diverse types of social knowledge.
4. Enable reflective practices.
5. Champion equity and justice.

Invest in the marine social sciences across all initiative phases

Capacities for strengthening the social sciences include allocating more funds, building infrastructure for engagement, data collection, analysis and reporting, as well as investing in early career scholars and career trajectories[12,54,61]. Furthermore, inclusion of social scientists into ocean assessment and monitoring processes can make important contributions towards recognizing social vulnerability and impacts. Other capacities involve making space for inclusion in decision-making areas, from the outset, such that marine social scientists have the opportunity to help shape agendas, flag issues and provide strategic guidance based on new or existing social knowledge. Working directly with social specialists by hiring, consulting, or enabling the capacity of teams across public, private sector, and non-governmental organizations is vital. The greatest benefits are expected where insights can be integrated early, into the design phase. Nonetheless, embodying the above recommendations will be most effective when they are integrated throughout all four initiative phases (i.e., design, implementation, evaluation, intention), across the major initiative areas in research, policy, management, development and funding.

Strengthen knowledge co-production

Individuals and organizations can advocate for, and make efforts to, create ocean knowledge that assesses problems and proposes solutions in an integrated and collaborative way. Weaving together the natural and social ocean sciences and the views and experiences of stakeholders has shown to be invaluable for creating spaces for innovative thinking based on different values, perspectives and worldviews to find sustainable solutions. Participatory and collaborative research and policy formulation directly with society is good practice, and has been shown to facilitate inclusion, transparency and trust[5,58,177,178]. Long-term engagement to build trust between different types of sciences and communities in local contexts to foster collaboration should be made possible by ocean sustainability initiatives. Illuminating potential barriers to co-production processes is a vital role for social scientists in interdisciplinary programs. This move towards alternative modes of knowledge production and policy formulation requires facilitating governance structures, including financial support for meaningful and boundary-spanning engagement of social scientists[58,60,61].

Leverage diverse types of social knowledge

Three forms of knowledge will enable science-based and informed decision-making to support ocean sustainability: these are system, target and transformative forms of knowledge[8,179]. System knowledge is related to how relational social, ecological and social-ecological systems work, including descriptive and analytical insights into their functional components and processes. Target knowledge understands desirable pathways, outcomes and futures, including the plausibility of different perspectives, targets, scenarios and visions. Transformative knowledge focuses on understanding and developing actionable pathways for effective interventions in society, and is applied where social systems are shifted towards desirable social-ecological outcomes. All ocean science disciplines are important for system knowledge. The marine social sciences are, however, essential for helping society to understand what it wants (social targets) and how to get there (social system change)[8]. Furthermore, we argue that the ontological and epistemic origins of our social knowledge base needs to be more diverse and inclusive of alternative knowledge systems, of course including Indigenous, local, and non-Western knowledge systems[94]. Our oceans, their challenges and potential solutions must be viewed from different perspectives towards a common future.

Enable reflective practices

There is a need to reflect on current practices within ocean initiatives, projects and organizations about what knowledge is being used, its limitations and what additional knowledge could be utilized or produced to inform decision-making. It is particularly important that within such cultures of practice, raising concerns, flaws and shortcomings are welcomed, as are alternative ideas and critical dialogue within the four initiative phases. Enabling reflection can also help create the conditions to move beyond current communication practices of scientific knowledge by embracing diverse ways of co-producing knowledge together in a way that welcomes and values different perspectives (i.e., epistemic practices). Moreover, the integration of diverse epistemic cultures of knowing and working within the ocean strengthens social cohesion between social groups which tend, especially in the current era, to polarize their opinions.

Champion equity and justice

Many people are dependent on the ocean, and if that dependency is eroded or broken, they will have few or no other livelihood options, or their culture will be lost or diminished. Moreover,

equity and justice are core values in all human societies, requiring them to be addressed. We have emphasized the lack of power of certain particularly vulnerable sectors of many societies over ocean governance and health, the forces affecting these and the viability of fishing-based livelihoods. Championing justice and equity for the disempowered not only means recognizing the rights and the emotional attachments of resource users and actors, but also requires empowerment of these stakeholders by diversifying the leadership, design, and implementation of ocean sustainability initiatives. Such initiatives cannot be sustainable without inclusivity and justice in planning and control. The inclusion of diverse people and voices in project teams and leadership paves the way towards engaging with the different intervention areas we have identified here more effectively by including a greater diversity of ideas, perspectives and approaches[178,180].

CONCLUSION

Positive social impacts and benefits are not inevitable features of ocean sustainability initiatives. This is clear for instance for interventions regarding species conservation, restricting habitat access, or the (non-consultative) quantification of ocean health, without reference to societal health. We have focused here on upending the norms prevalent in ocean research, management, development, funding and policy making. The five intervention areas, along with our set of recommendations for implementation, provide a template for increasing the likelihood that ocean sustainability initiatives can deliver comprehensive and equitably distributed benefits and avoid harms. Strengthening the marine social sciences is key, and it should be more than a technical or tokenistic exercise or add-on. We encourage individuals, teams and organizations involved in ocean sustainability initiatives to consider the five thematic areas in tandem with the set of recommended actionable practices. Our five proposed areas – on ethics, governance, behavior, impacts and partnerships – are elaborated and well documented in a range of research activities.

Our article is a shared effort to synthesize lessons from the literature as well as from our expertise and experiences to distill new and integrative perspectives, to shift research towards co-productive inter- and transdisciplinary collaborations. Global multilateral pledges, for example, to increase marine biodiversity protection, to phase out marine litter, or to generate an equitable Blue Economy that increases the well-being of those most in need, won't manifest as long as the social sciences are only contributing 5% of the knowledge on our oceans. More balanced inputs are urgently needed for the benefit of science and society. Our five intervention areas offer guidance for why this is important and where to focus future investments for marine social sciences.

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AUTHOR CONTRIBUTIONS

S.P. and A.S. designed and conceptualized the study with inputs from A.B. and R.S. S.P. collected and analyzed the data. All authors contributed qualitative data to the study. S.P. led the writing and editing of the paper. All authors contributed to revising and editing the manuscript. S.P. coordinated the project.

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