Emergence of a global science–business initiative for ocean stewardship

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The ocean represents a fundamental source of micronutrients and protein for a growing world population. Seafood is a highly traded and sought after commodity on international markets, and is critically dependent on healthy marine ecosystems. A global trend of wild stocks being overfished and in decline, as well as multiple sustainability challenges associated with a rapid growth of aquaculture, represent key concerns in relation to the United Nations Sustainable Development Goals. Existing efforts aimed to improve the sustainability of seafood production have generated important progress, primarily at the local and national levels, but have yet to effectively address the global challenges associated with the ocean. This study highlights the importance of transnational corporations in enabling transformative change, and thereby contributes to advancing the limited understanding of large-scale private actors within the sustainability science literature. We describe how we engaged with large seafood producers to coproduce a global science–business initiative for ocean stewardship. We suggest that this initiative is improving the prospects for transformative change by providing novel links between science and business, between wild-capture fisheries and aquaculture, and across geographical space. We argue that scientists can play an important role in facilitating change by connecting knowledge to action among global actors, while recognizing risks associated with such engagement. The methods developed through this case study contribute to identifying key competences in sustainability science and hold promises for other sectors as well.

coproduction | governance | learning | resilience | transformation

Sustainability science is becoming a mainstream scientific approach for understanding and addressing the global and interconnected challenges currently facing humanity (1, 2). A key component of sustainability science is to collaborate with actors outside of academia to codesign and codevelop an understanding of the challenges and their corresponding solutions (2, 3). Local and regional examples illustrate how sustainability scientists have engaged with society as change agents (4, 5) and the challenges associated with such engagement (3, 4, 6, 7). In this context, however, there has been limited attention devoted to large-scale private actors (8). Existing studies primarily focus on how major brands invest in—and benefit from—sustainability initiatives (9), or analyze how and when voluntary commitments to sustainability may influence corporate behavior (10, 11). Little is known about how scientists can engage with corporations and how knowledge can be transferred from science to action by the private sector.

In the following, we present our experience from a coproduction process with large transnational seafood corporations, aimed at stimulating transformative change in the seafood industry, and the subsequent emergence of a global initiative for ocean stewardship. Here, ocean stewardship is viewed as an adaptive and learning-based, collaborative process of responsibility and ethics, aimed to shepherd and safeguard the resilience and productivity of ocean ecosystems for human well-being. Stewardship of the ocean—as part of the broader biosphere that humanity is embedded in and dependent upon—is essential if sustainability on a human-dominated planet is to be taken seriously (12).

We describe how we identified seafood production companies with which to address the ocean stewardship challenge, and elaborate on how we progressively codesigned a process for mutual learning. We discuss how this process can influence sustainability in the seafood industry, reflect on the risks associated with engaging with the private sector, and consider how our experience can guide methods development and training in sustainability science. While such engagement may appear beyond scientific comfort zones, we argue that working with the private sector, and at the global level, can provide important insights to the developing field of sustainability science.

The Scientific Process: An Empirical Starting Point

While there is a growing literature associated with seafood and its associated sustainability challenges (*SI Appendix*, *Text S1*), Jacquet et al. (13) argue that addressing these challenges requires appreciation of asymmetrical impacts on sustainability from disproportionally large actors. The first step of the process of emergence described here consisted of an empirical case study designed to identify corporations with direct influence on marine ecosystems at the global level. Our goal was to better understand revenues and production volumes of the largest seafood companies. In particular, we wanted to know how much seafood these companies were handling, what species they were catching or producing, from where, and especially if such activities influenced the dynamics of marine ecosystems and their resilience (14). We were inspired by a classic study in ecology,

Significance

The ocean is under considerable pressure originating from diverse human activities on land and in the water. While substantial literature has focused on how science interacts with policy, relatively little is known about interactions between science and business. Here, we describe: (*i*) the process of identifying "keystone actors" in marine ecosystems, namely globally operating corporations engaged in fisheries and aquaculture, with a unique ability to influence change and take on a leadership role in ocean stewardship; (*ii*) how we actively engaged with these actors, to collaboratively develop solutions to the ocean sustainability challenge; and (*iii*) how this coproduction process led to the establishment of a unique global ocean initiative, where science and business collaborate toward the United Nations Sustainable Development Goals.

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describing the concept of "keystone species"—species with a disproportionate impact on the structure and function of ecosystems—and how they can trigger cascading ecological effects (15–17). Our first hypothesis was that: the largest seafood companies constitute "keystone actors" in the Earth system, with a disproportionate ability to influence the dynamics of marine ecosystems around the world.

Using multiple sources of information over a period of 2 y (Fig. 1), we collected and analyzed empirical data illustrating that 13 seafood production companies accounted for 11–16% of global wild marine catches, and that only a few of them together controlled 19–40% of some of the largest and most valuable wild stocks, critical for the dynamics of marine ecosystems (14). They also occupy a dominant position in important segments of aquaculture (e.g., salmon and shrimp) and in feeds production. We refer to these companies as keystone actors, as they are vertically integrated (some operating across entire supply chains from production through to retail), dominate all segments of seafood production, are connected globally through an extensive network of subsidiaries, and play a disproportionate role in the dynamics of marine food webs around the world (14). We also found that they are actively involved in fisheries and aquaculture decision-making processes, which led to our second hypothesis: namely that these companies have a disproportionate ability to influence change in the global seafood industry (14). The identified companies could thus potentially play a critical role for ocean stewardship, managing not only the stocks they are harvesting or species they are producing, but also the wider seascape in which they operate and upon which they depend.

The Codesign Process: Establishing Initial Trust

Based on the identification of keystone actors, we set out to conduct a global experiment to test whether these companies have an interest and ability to take on a leadership role for ocean stewardship. Our ambition was to bring the CEOs of all keystone actors together with scientists for a strategic and science-based dialogue about the future of seafood and marine ecosystems. The most challenging and time-consuming aspects of these preparations involved establishing initial trust with CEOs and convincing them that a meeting of this sort could add value not only to their operations, reputation, and brands, but also in terms of clarifying their responsibility as global actors and the significance of ocean stewardship for sustainability and prosperity. A prerequisite for initiating this process critically involved finding the means to meet face-to-face with the respective CEOs.

The process of producing the article on keystone actors (14) resulted in many interactions with some of the relevant companies, and an increased dialogue between science and business. We established working relations with ambassadors around the world that could facilitate access to the respective companies' CEOs. Eventually, we were able to engage in bilateral meetings with leading representatives from the seafood industry in Tokyo, Seoul, and Bergen (Fig. 1). Some CEOs were not able to meet with us in person, and instead we set up telephone conferences to establish a working relationship.

During these meetings, we presented ourselves as independent sustainability scientists working at a public university in Sweden. We described that our scientific perspective is to regard humans as an embedded part of the biosphere, and our recognition of the Anthropocene as a new geological epoch where humans have become a major force in the operation of the Earth System and its biosphere (18). Human impacts were presented as having exceeded several planetary boundaries, beyond which large-scale and potentially irreversible environmental change can be anticipated (19). We also described our recognition that globalization has generated a world of prosperity for many, a world that is extensively connected, through trade and communication networks (20), but also through global actors, such as transnational corporations keeping the web of interconnections together. We argued that keystone actors potentially have a disproportionate

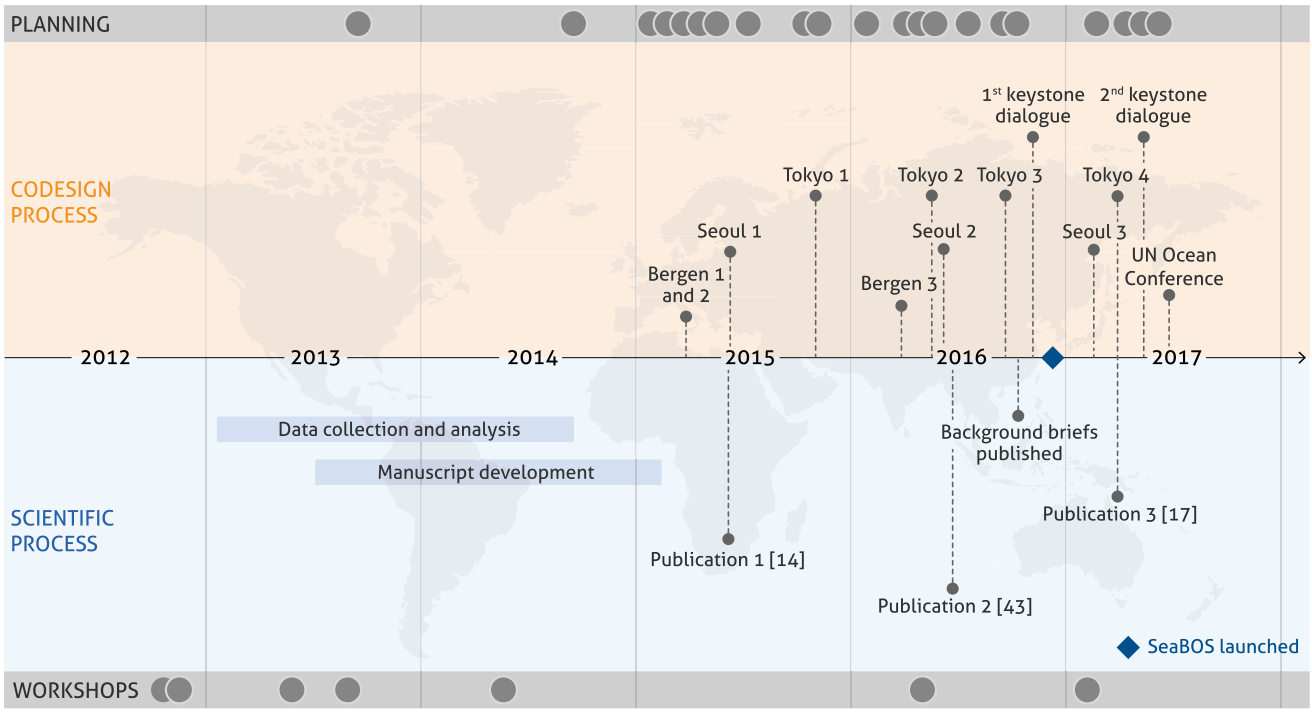

Fig. 1. Emergence of a global science–business initiative. Timeline illustrating the scientific process of developing and publishing relevant knowledge (*Lower,* blue) and the corresponding codesign process of multiple dialogues between scientists and business representatives (*Upper*, orange). *Lower* circles represent key scientific workshops; *Upper* circles represent planning meetings for the two keystone dialogues.

ability to stimulate transformative change toward sustainability (14) as well as the responsibility to do so. These meetings represented an opportunity to listen to, learn from, and understand the priorities of CEOs, while also engaging with them in discussions about the opportunity for the seafood sector to actively contribute toward achieving the global Sustainable Development Goals (SDGs). Multiple and repeated interactions with company representatives (Fig. 1) provided important guidance for what issues to focus on, as well as how to design additional meetings and associated background material.

The outcome, in cases where it became clear that there was potential for further collaboration, was that the CEO (or a company representative) agreed to participate in an "exclusive, informal, and trust-based gathering of global seafood industry leaders and scientists," that aimed to explore "transformative risks and opportunities for the global seafood industry." The meetings before this first keystone dialogue clarified that industry representatives were interested in engaging with science, but apprehensive to the presence of agenda-driven organizations, such as environmental nongovernmental organizations, at the dialogue.

The First Dialogue: Collaborative Learning in Practice

The first keystone dialogue (Fig. 1) took place in a setting that was well suited for an informal and strategic discussion, with significant room left in the agenda to facilitate casual interactions. Social activities were part of the program, as an additional and important opportunity for participants to get to know each other and to build trust. The dialogue featured representatives from eight of the world's largest seafood companies, headquartered in Japan, Korea, Thailand, Norway, the Netherlands, and the United States, including the two largest seafood companies by revenue, two of the largest tuna companies, the two largest farmed salmon producers, and the two largest aquafeed companies, as measured in production volumes.

The meeting agenda (*SI Appendix*, *Text S2*) covered 2 d, where the first day focused on transformative risks. An introduction by the dialogue Patron, Her Royal Highness Crown Princess Victoria of Sweden, expressing her concerns and expectations, was followed by a scientific presentation describing the global and interconnected challenges of the Anthropocene, and a roundtable reflection from CEOs about their perceived major challenges associated with seafood production. The first day ended with a sense of urgency and consensus recognition that the group overall had a shared understanding of the challenges.

The second day focused on opportunities and started with a scientific and empirically based understanding of how policy entrepreneurs can navigate processes of change associated with ecosystem management (21), with a particular focus on how industry actors in seafood had reduced illegal, unreported, and unregulated fishing in the Southern Ocean (21). Presentations from advisors followed, and included information on key innovations in the industry, market trends, and policy developments, and a discussion about corporate sustainability leadership in other sectors. Discussions and breakout sessions on the second day focused on finding ways in which the industry could actively engage in collaboration for ocean stewardship. Major outcomes included recognition that: (*i*) keystone actors and scientists have much to learn from each other, (*ii*) the group wanted to continue with the collaboration and meet again, and (*iii*) there was a consensus agreement of the value in producing a joint statement defining the ambition of this initiative.

The Initiative: Seafood Business for Ocean Stewardship

The first meeting was initially only intended to represent a platform for a dialogue between science and business, and an opportunity to build trust for possible future collaborations. However, it generated a statement in the following weeks that laid the foundation for a new global coalition, entitled "Seafood Business for Ocean Stewardship" (SeaBOS), and aimed to lead a transformation of global seafood production for a healthy ocean (www.keystonedialogues.earth) (*SI Appendix*, *Text S3*).

The commitments from keystone actors to engage in a global coalition exceeded the expectations from the organizers and several participants. The SeaBOS initiative was perceived by companies to be unique, as it successfully connected (*i*) science and business, (*ii*) wild-capture fisheries and aquaculture, and (*iii*) companies from the three major markets for seafood (22). None of these three dimensions were perceived to exist in any other context.

The areas in focus of SeaBOS reflected the initial discussions with industry leaders but also contained additional aspects that surfaced during the dialogue. Forced and bonded labor and the challenges associated with antibiotics represent notable examples. Many of the major areas in need of improvement in seafood production (*SI Appendix*, *Text S1*) are included in the statement (*SI Appendix*, *Text S3*), such as increasing transparency, reducing illegal, unreported, and unregulated fishing, eliminating forced and bonded labor, improving fisheries and aquaculture management, reducing the use of antibiotics in seafood production, and addressing climate change, among other issues; these priorities are thus very much in line with the targets of Goal 14 ("conserve and sustainably use the oceans, seas, and marine resources") of the SDGs (23).

Notably, the statement highlights not only the responsibility of the seafood industry but also the importance of governments to address many of the challenges associated with unsustainable seas generated by activities beyond the seafood sector, including ocean pollution and climate change.

The Second Dialogue: Moving from Words to Action

The second keystone dialogue (Fig. 1) included participation from two additional companies. The setting was more formal than the first dialogue, and focused on "Advancing the Seafood Business for Ocean Stewardship Initiative." The meeting agenda (*SI Appendix*, *Text S4*) featured updates from individual companies and scientists, as well as a summary of priorities identified through bilateral conversations between the first and second dialogues. Diverse opportunities for further collaboration were identified by the end of the first day. The second day featured task-oriented conversations in breakout groups, where priorities were developed, along with tangible targets and actions.

The meeting concluded with an agreement that SeaBOS members would now formalize governance and funding mechanisms of the initiative. They will also engage in four operational task forces over a period of 1 y, until the third dialogue, focusing on advancing the first four priorities expressed in the joint statement from the first keystone dialogue (*SI Appendix*, *Text S3*). These commitments were presented at the United Nations Ocean conference in New York 1 mo later (Fig. 1 and *SI Appendix*, *Text S5*).

Our experience with the first two keystone dialogues closely mirrored previous work associated with managing the boundary between knowledge and action. Scientific knowledge directly supported the dialogues through presentations and background briefs, which were in line with key issues of concern expressed during bilateral meetings and produced in collaboration with leading scientists. Our experience highlighted the importance of gaining trust, expanding on existing initiatives and generating new connections between actors (5), cultivating personal relationships with all major stakeholders (including SeaBOS members, but also other actors engaged in related seafood sustainability initiatives), respecting different norms and knowledge, meeting in a neutral setting for shared knowledge production (24), and the importance of translation to facilitate conversations across cultures and languages (25).

Will the Initiative Influence the Seafood Industry?

Previous work on knowledge exchange between scientists and decision-makers (26) suggest that SeaBOS is best described as a coproduction initiative between science and business, in which companies can develop their agency (27), to influence change across subsystems, thereby contributing to amplifying new norms of ocean stewardship. Outcomes from the two dialogues suggest that keystone actors have an interest in operating as global norm entrepreneurs (28), setting new agendas, standards, and ways of operating, which can potentially cascade through the seafood production system and also influence other actors shaping the ocean. Keystone actors can bridge knowledge systems and contribute to connecting companies, regions, and technologies based on a vision of ocean stewardship for the benefit of mankind. Similar examples of norm entrepreneurs are, for example, found in relation to environmental reporting schemes in national electricity sectors (29), environmental standards for the financial sector (30), and voluntary sustainability reporting for companies in general (31).

There are no guarantees that this will happen, however. Previous experiences with voluntary environmental commitments show mixed results and illustrate the importance of audits, disclosure, and sanctioning mechanisms to ensure changes in behavior (10). For example, the United Nations Global Compact, aimed to improve environmental, human rights, and labor policies among private actors, is lacking both monitoring and enforcement mechanisms. While members generally show improvements in superficial dimensions, they harvest benefits associated with membership without making more fundamental changes (32). Membership in ISO 14001 on the other hand, with its third-party auditing system, is associated with improved environmental performance (33). Both Global Compact and ISO 14001 have a positive reputation and are open to all members. While the SeaBOS initiative is not an established brand to the same extent, nor is it open to all seafood companies, it represents a platform with a unique capacity to connect and complement other existing initiatives (*SI Appendix*, Fig. S2 and Table S1).

Previous studies have highlighted that the stringency of standards in voluntary commitments, need to take into account the population of members (11). The small group of members in SeaBOS, combined with the trust-based, face-to-face *modus operandi*, makes it different from many existing global green clubs (33). Further engagement with SeaBOS members will determine adequate monitoring and enforcement mechanisms.

Transformative Capacity

Theoretical and empirical work (34, 35) indicate that the capacity of a system to undergo transformative change is directly related to its degree of connectivity (36). A loosely connected system is less prone to transformative change, whereas a highly connected system is more prone to critical transitions (36). Increasing the connectivity of a system thus represents a potential pathway toward transformative change at large scales and across subsystems.

Existing industry sustainability initiatives (*SI Appendix*, Table S1) currently reflect the emergence of efforts within individual segments of seafood production. From a theoretical, complex adaptive-systems perspective (34), segment-specific initiatives and coalitions generate a number of microinteractions (standards, practices, and norms) that can cascade within subsystems of seafood production (e.g., within tuna fishing or salmon farming). However, if such subsystems are poorly connected, companies would have limited ability to share insights and learn from the experiences of others.

The process described here increased the connectivity between seafood companies engaged in existing sustainability initiatives (*SI Appendix*, Fig. S2) by facilitating information flow and learning across individual components of a global production system. Previous empirical work suggests that improved information sharing in social networks can lead to desirable environmental outcomes (37), whereas theoretical work underlines the importance of functional diversity among actors when successfully addressing problems (38). Increased network connectivity among the diverse companies observed in this study (Fig. 2) is therefore likely to generate an improved capacity to deal with complex problems.

The seafood industry is rapidly consolidating and becoming increasingly connected, through horizontal and vertical integration (14), thereby also changing the power dynamics of the entire sector (9). The small group of 10 companies committed to the SeaBOS initiative is able to influence the strategic direction of more than 639 subsidiaries with operations in at least 93 different countries (14). This connectivity is creating new incentives for integrating sustainability concerns, because companies are operating on all continents, making them aware of the sustainability standards and requirement of all major markets.

However, the sector is still relatively fragmented in different segments: for example, as illustrated by companies primarily catching tuna, whitefish, or small pelagic species, or engaging in aquaculture or in feeds. There also seem to be three major regional clusters of corporations based primarily in Asia, Europe,

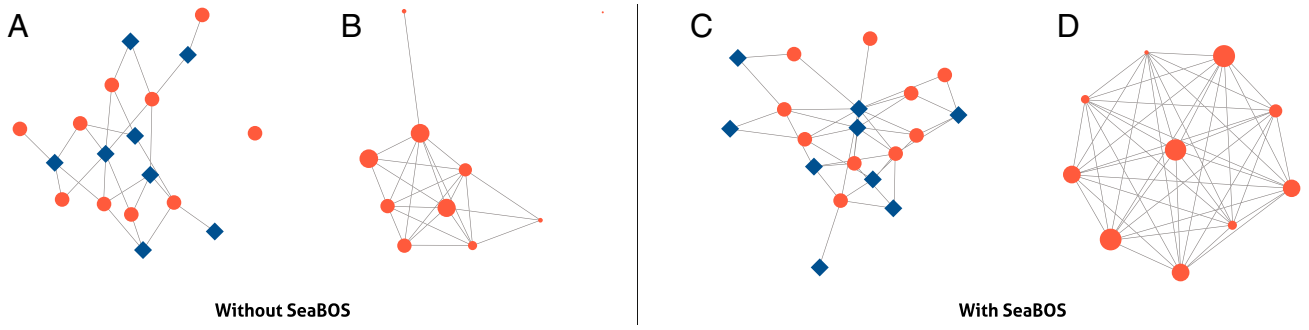

Fig. 2. Increasing global connectivity in the seafood industry. Bipartite networks of 10 companies participating in the dialogues (red circles) and their membership in international seafood sustainability initiatives (blue diamonds), without (*A*) or with (*C*) SeaBOS. *B* and *D* represent one-mode company-network projections, where node size corresponds to the node degree (number of initiatives the company is connected to). The network density (connectivity) increased from 53% (*B*) to 100% (*D*) by design through the establishment of SeaBOS. The minimum degree (smallest number of connections of any node) increased from 0 (*B*) to 9 (*D*). For *A* and *C*, network density increased from 16 to 20%, and minimum degree from 0 to 1, respectively. Note the isolated company (not connected to any initiative) in *A* and *B*. See *SI Appendix*, Fig. S2 for names of initiatives and companies, as well as one-mode initiative-network projections.

and North America, corresponding to the three dominant markets for seafood (22).

Multiple and mutually reinforcing norms are developing within seafood production (39) and we can only speculate whether or not these dialogues represent a social tipping point (40), encouraging companies to better integrate sustainability as a core value in their operations (9). The fact that there is limited cooperation and technology transfer between different sectors or regions likely motivated some participants to engage in this initiative, as interaction with other keystone actors can enable mutual business benefits. However, incentives derived from consumer demand and sustainability commitment from major retailers (*SI Appendix*, Fig. S1), combined with policy developments, social norms, reputational risks, the current pace of innovation, and novel financial mechanisms, are all stimulating more sustainable production (9), including in the seafood industry (39, 41–43).

Risks Associated with Engaging the Private Sector

The relationship between science and industry, from a sustainability perspective, is one often characterized by conflicts and mistrust, where powerful transnational corporations can be associated with environmental degradation and negative social impacts. Engaging with industry can influence perceived scientific credibility if resulting activities are nothing but green washing from companies with little intention of changing. Such risks may in part explain the limited experiences of science–business collaboration in the sustainability-science literature. The initiative presented here is still in an early phase of development, and additional work is required to assess the level of engagement in the voluntary commitments made. This is an experiment that we will monitor continuously, while remaining financially independent from SeaBOS members.

We are engaging with keystone actors from a theoretically informed perspective, backed by empirical observation of consolidation in the seafood industry and the potential impacts on materiality, not from political conviction. We treat the size and importance of keystone actors as an objective fact and a central phenomenon of the Anthropocene, rather than an expression of support for industry consolidation or current economic models.

The effects from SeaBOS may be positive, by influencing other companies to increase their commitments to sustainability (17), but there may also be negative side effects. Privatization in fisheries and aquaculture has resulted in negative impacts (e.g., unemployment or reduced income), often on actors with limited power (44, 45). An increasingly prominent role of private actors in global governance raises issues associated with accountability, fair representation, and global equity (9). Stringent sustainability standards applied by key market actors in other sectors have had negative downstream effects. However, proper capacity building (including by companies) and regulations by governments can mitigate such negative impacts (9).

Nations of the world have promised to deliver on the SDGs by 2030, but the challenges associated with mobilizing effective governance mechanisms are substantial (46). Complementary and alternative mechanisms for change at local but also global scales are thus needed. Given the magnitude of the challenges associated with the ocean, the slow pace of progress, and the obvious interconnectivity with other SDGs (23), we regard our work with companies engaged in production as a relatively unexplored—yet critically needed niche—to complement efforts focusing on consumption and public policy (*SI Appendix*, *Text S1*).

Implications for Sustainability Science

The process of emergence presented here illustrates potential ways in which science can facilitate information flow and learning, increase systems connectivity, and thereby enable transformative change (36). Our findings contribute to further stimulating the scientific discussion about potential avenues in which scientists can strategically operate with integrity as empirically informed and hypothesis-driven change agents (4, 5).

A substantial literature has developed around how science interacts with policy (26, 47), but relatively little is known about interactions between science and business. Further work should explore both similarities and differences between these two settings. The objectivity and trust associated with scientists, compared with stakeholders with explicit advocacy agendas, makes the science–business dialogue a potentially unique and effective approach to engage with business for biosphere stewardship. Our assessment is that the open and constructive discussion about how to integrate sustainability into seafood business models was critically dependent on the perceived saliency and legitimacy of independent science, as well as the trust developed during bilateral meetings and the global dialogues.

Insights from experiences with process-oriented sustainability science illustrate that scientists can take on a range of different roles in sustainability transitions (3). Sustainability science, and boundary work between knowledge and action in particular (5), require a range of different competencies, including systems-thinking competence, normative competence, anticipatory competence, interpersonal competence, and strategic competence (48). We concluded that combined, we had (or were able to mobilize) sufficient knowledge, skills, and social capital for this global science–business process, and a moral imperative to do so (28). Our own normative values—that humanity is fundamentally dependent on a healthy biosphere and a resilient ocean—became evident to participants of the dialogues.

The roles we took in this process were similar to those observed at local scales (3), namely as reflective scientists (when analyzing the dynamics and actors before the dialogue), as process facilitators (when initiating the process, selecting participants, facilitating the learning process and encouraging expression of all view points), as change agents (by initiating a learning journey based on sustainability values and networking with stakeholders outside the group), as knowledge brokers (providing support to make sustainability meaningful in the seafood context), and finally as self-reflecting scientists (by engaging competences and capacities we were lacking).

Conclusions

Interaction between knowledge and action can take place in multiple forms, ranging from knowledge coproduction between scientists and decision-makers, to boundary organizations, which are specifically mandated to act as independent intermediaries between science and policy (25, 26). This initiative was not designed to develop into a coproduction initiative from the onset, but it emerged as such. The process was conceived to explore a scientific hypothesis, resulting from a curiosity-driven empirical science endeavor aimed to identify key actors of a globally interconnected world and to understand their capacity to influence change.

Sustainability science has been described as a "different kind of science that is primarily use inspired ... with significant fundamental and applied knowledge components, and committed to moving such knowledge into societal action" (49). Kates (49) also concluded that "its real test of success will be in implementing its knowledge to meet the great environment and development challenges of this century." Our study demonstrates that scientists can address such challenges with integrity as theoretically and empirically informed honest brokers (50). The potential of this initiative to generate cascading effects in the seafood industry is interesting, as is the process of continuing to evaluate the validity of our working hypothesis. Observations of industry consolidation in the seed industry (51) or private actors with large carbon dioxide emissions (52) suggest that similar approaches could be taken to stimulate novel thinking in other sectors as well.

The similarities between our attempt to trigger a global transformation and experiences at other geographical scales (3) emphasize that there is a clear role for science and scientists within this area of work. While some researchers are trained to explore the frontiers of space and others are trained to explore the depths of the ocean, we conclude that sustainability scientists need to be adequately trained, and provided with the space, to go deep into processes associated with global transformative change.

Materials and Methods

This study applies transdisciplinary research approaches (4) to the largest actors in the global seafood industry, thereby informing methods development in sustainability science. The network analysis relies on publicly available data about companies' membership in international seafood sustainability initiatives, cross-checked through a collaborative exercise with all participating companies for consistency and missing data. Networks were constructed and analyzed in R (53) with the package *igraph* (54).

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