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The Global Pandemic Has Shown We Need an Action Plan for the Ocean

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INTRODUCTION

The COVID-19 pandemic is the first serious test of how science can inform decision-making in the face of an immediate global threat, yielding important lessons on how science, society and policy interact. The global societal and economic impact of COVID-19 has shown that we need to assess, plan and prepare for potential future changes. These insights are particularly important for the ocean science community because of the global connectivity of the ocean and its crucial role in the Earth's climate system and in supporting all life on Earth. With climate change already impacting society and ecosystems, implementing mitigation measures to avoid and reduce emissions of greenhouses gases is an immediate priority (IPCC, 2021). Irreversible changes are already underway in the oceans and their impacts over the coming decades will continue to affect human communities, requiring societal responses and adaptation across multiple scales (IPCC, 2019, 2021).

The importance of the ocean in the Earth's climate system, influencing weather patterns and affecting sea level, is now recognized by governments and increasingly so by the public. Less well-appreciated is the central role of the ocean in maintaining ecosystems and biodiversity and in supporting human systems. Approximately 680 million people live in low-lying coastal zones, and ocean and coastal economies support millions of people globally (Ebarvia, 2016; IPCC, 2019). The global economy associated with our coasts and ocean (the "Blue Economy") is estimated to have an asset base of over US$24 trillion ($24 \times 10^{12}$) and generates at least US$2.5 trillion each year from the combination of fishing and aquaculture, shipping, tourism, and other activities (OECD, 2016). Nevertheless, marine systems across the planet are being altered because of climate change and human activity with impacts at local to global scales (e.g., Allison and Bassett, 2015; He and Silliman, 2019; IPCC, 2019; UN, 2021). These changes are unprecedented, threatening the capacity of the ocean to maintain crucial services to the planet and human communities (ecosystem services), including those that provide (e.g., food, water, and economic security), regulate (e.g., climate), support (e.g., nutrient cycling) and are cultural in their nature (e.g., traditional or recreational use) (IPCC, 2019; Sala et al., 2021) and so are increasing the potential for societal conflict.

The challenge is urgent. There is an immediate requirement to go beyond calls for action to deal with aspects of the impacts of climate change and human activities on the ocean (IPCC, 2019; UNESCO-IOC, 2021). An *Action Plan for the Ocean* is needed that develops a comprehensive global understanding of and plan for dealing with multiple ocean risks, that is flexible and adaptive as knowledge expands and new threats arise. The urgency of the challenge requires an internationally coordinated effort that draws on existing global research capacity and networks; a key opportunity presented by the *UN Decade of Ocean Science for Sustainable Development* 2021-2030 (UNESCO-IOC, 2021) that must not be missed if we are to minimize change in ocean systems and impacts on the services they provide to society.

THE IMPORTANCE OF ASSESSING RISK TO MANAGE RESPONSES TO OCEAN CHANGE

An awareness of risk is necessary to prepare responses to an uncertain future. The COVID-19 pandemic provides a timely insight into what can happen if there is not full awareness of risk, or if available information on risk is not acted upon and appropriate planning put in place. Over almost two decades, national and international risk assessment activities have made it clear that the likelihood of a global pandemic occurring and causing massive international, social and economic disruption was very high (e.g., Ross et al., 2015; WHO, 2017). Yet, when the COVID-19 pandemic surged across the world, the response was (and continues to be) variable (Dewi et al., 2020), being slow, poorly coordinated or even conflicting at both national and international levels in many regions. As the pandemic continues, insights into what went wrong, what went right and what should happen next are beginning to emerge (Dewi et al., 2020; Weible et al., 2020). These insights are relevant to the ocean science community because the impacts of major changes in the state of the ocean will likely far exceed the global social and economic consequences of the COVID-19 pandemic.

The financial cost of the COVID-19 pandemic is uncertain, with early projections suggesting trillions to 10 s of trillions of US dollars over 5 years (WEF, 2020). Losses associated with climate change impacts on the ocean are likely to be at least of similar magnitude and will continue to develop for decades. Without mitigation and adaptation measures, sea level rise scenarios project annual losses of 0.3–9.3% of global GDP by 2100 (IPCC, 2019; equivalent to ∼US$0.25 to US$7.88 trillion per year based on 2020 GDP, World Bank, 2021), while losses from declines in ocean health and services by 2050 are projected to be US$428 billion per year, and by 2100 US$1.979 trillion per year. Under high emission scenarios, global fisheries revenue is projected to decline by over 10% over the next three decades, resulting in an annual reduction of between US$6 and US$15 billion (Lam et al., 2016). However, the recent IPCC (2019) report on the state of the ocean demonstrates the general lack of knowledge of the cost of many of the potential impacts at different scales.

The risks to societies and economies arising from natural or human-driven changes in the ocean have similarly been recognized by the scientific community and highlighted to governments and the public numerous times (e.g., IPCC, 2019, 2021; UN, 2021). Although general societal awareness of these risks is increasing (e.g., ORRAA, 2021), there is a need to ensure that the risks to the ocean, and associated human well-being, are fully understood and lead to appropriate planning and action to reduce or manage those risks. To support this, decision-makers need the relevant information and tools to make the necessary decisions at the appropriate time (Evans et al., 2019).

Building the information systems and tools for facilitating understanding and timely and appropriate decision making requires a coordinated transdisciplinary global effort linking natural, social and economic sciences (Rosa et al., 2017; Laffoley et al., 2020; Norstrom et al., 2020; Pendleton et al., 2020; UNESCO-IOC, 2021). Over the last decade, a number of programmes and projects have driven international efforts to develop the integration of human systems in global ocean ecosystem science, including the Integrated Marine Biosphere Research (IMBeR) project (Hofmann et al., 2015) to which the authors contribute.

We call on the ocean science community to unite to develop an *Action Plan for the Ocean* that underpins sustainable development and ensures that adaptive responses to global, regional and local risks are agile, well-coordinated, effective and equitable. We suggest that this is the grand challenge for ocean science for the 21st century. To help meet this challenge, the *UN Decade of Ocean Science for Sustainable Development* 2021-2030 (UNESCO-IOC, 2021) provides an opportunity to build global support systems for informing decision making on the critical time scales of the coming years and decades.

AN *ACTION PLAN FOR THE OCEAN*

We propose a three-component process to develop an *Action Plan for the Ocean* (**Figure 1**): (1) assess and rank risks, (2) identify options for action, and (3) develop action plans for adaptation at local, regional and global scales to respond to future change. This process needs to be continuously updated as new information becomes available and understanding improves.

1. Assess and Rank Risks

The second World Ocean Assessment (UN, 2021) provides the most up-to-date and comprehensive view of the state of the ocean, including human uses and benefits, and identifies declines in the services the ocean provides to society. In addition, there are numerous specialized and focused assessments of aspects of the ocean system and risks associated with change (e.g., Laffoley and Baxter, 2018; IPBES, 2019; IPCC, 2019, 2021; Singh et al., 2021). The challenge now is to develop an understanding of the relative importance of different potential risks to the ocean. This requires consideration of which risks are most likely, which could have the greatest impacts, across what time scales these might occur and which components of the ocean and society would be most severely affected (e.g., Mace et al., 2015; Holsman et al., 2017; Weaver et al., 2017; Laffoley et al., 2020; Singh et al., 2020). To develop this component of the action plan, a coherent framework for quantifying risk across scales is required.

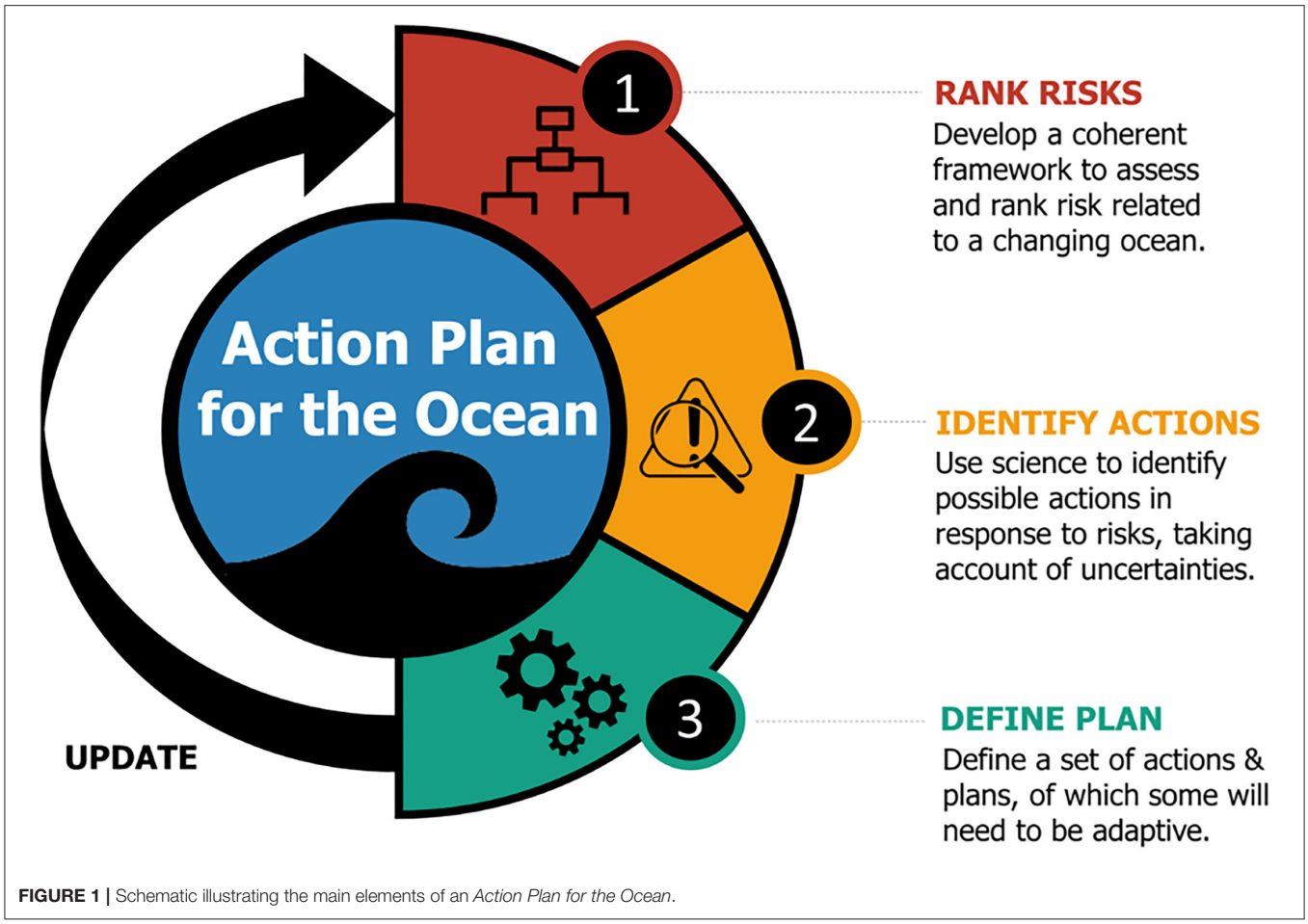

FIGURE 1 | Schematic illustrating the main elements of an *Action Plan for the Ocean*.

This can draw on knowledge and experience in the development and implementation of risk-based approaches within the context of conservation and sustainable development (e.g., Smith et al., 2007; Hallegatte and Rentschler, 2015; Holsman et al., 2017). Developing a risk-assessment framework as part of the action plan also requires that the language used, and the approaches and methods applied, are both widely understood and appropriate. Improving literacy in society of definitions of risk and the likelihood and scale of resulting impacts is crucial. Developing the framework will also necessitate improved understanding of what particular risks to the ocean mean for society and its diverse members, who have different perspectives and value systems, in order to prioritize risks in a range of contexts (Laffoley and Baxter, 2018; Pendleton et al., 2020; Singh et al., 2021).

2. Identify Options for Action

Based on a comprehensive assessment and ranking of risks (Step 1), options for action should be developed in an inclusive approach, to generate science-based, viable and deployable strategies for responding to current and potential future risks. These options for action should consider what happens if/when a particular event or set of events occurs using different approaches, and what might be appropriate pre-emptive actions and responses (IPCC, 2019; Laffoley et al., 2020). This requires an understanding of both the multiple direct effects of change, as well as a wider exploration of potential knock-on effects, interactions and consequences. It will also require analyses of alternative strategies and solutions, including for example, ecosystem-based/nature-based solutions that consider biodiversity and ecosystem-based management activities (IPBES, 2019; IPCC, 2019). Some risks may develop gradually, providing time to adapt and therefore allow for the implementation of actions in a stepwise manner. Other risks may occur rapidly, through shock events, an increasing frequency of extreme events or change occurring at thresholds or at tipping points (IPCC, 2019; Heinze et al., 2021), requiring immediate mitigation and adaptation actions. Developing such options for action extends the concept of scenario development beyond that used for exploring changes to climate and the ocean or biodiversity (e.g., IPBES, 2019; IPCC, 2019, 2021). It is crucial that in developing options for action, all interests and perspectives are represented. This must include indigenous and local communities, who are often most directly exposed to multiple risks associated with ocean change, and who also have valuable long-term knowledge and perspectives that can inform the development of options (Allison and Bassett, 2015; Singh et al., 2021). Development

of options for action will also require enhanced routes for collaboration and communication between decision-makers and science advisory bodies and the development of new approaches to the leadership of societal responses to change and rapidly occurring events or hazards based on an understanding of risk (Few et al., 2020).

3. Define Action Plans

Based on the ranked assessment of risk (Step 1) and identification of potential actions (Step 2), action implementation plans will need to be developed. These would outline that for a given scenario X, action plan Y including actions A, B, and C will need to be implemented and supported via enhanced knowledge of specific processes D, E and F. To be effective, agreement on reducing risks, and mitigating and enacting pre-emptive actions will be a priority. The ocean-science community in its widest and inclusive sense is well-placed to provide tools for exploring the implementation of actions to support such a planning process. The marine science community has already developed such decision-based and adaptive approaches in some aspects of conservation and management. For example, harvest control rules used in fisheries provide a series of agreed guidelines that determine appropriate catch levels or management actions within a fishery based on agreed indicators. Nested action plans should be developed inclusively at local, regional and global scales (Rosa et al., 2017; Singh et al., 2021). They should also be coordinated so that best practices and resources required for effecting and implementing plans are shared and consistent across scales and agreed responses are developed and evaluated before they are needed. The step-based and cyclical structure for the development of the *Action Plan for the Ocean* will allow for continuous updating as new insights are gained and risks reassessed, similar to that already in place within other processes that regularly assess ocean environments (e.g., IPCC, the World Ocean Assessment and IPBES).

COORDINATION FOR ACTION

The World Health Organization (WHO) was able to monitor and communicate the development of COVID-19 so that universal information and warnings were provided for developing responses in a rapidly changing environment. Currently there are multiple international and national bodies and independent organizations generating assessments of the state of the ocean and the likely impacts of future change. Governance and management in the world's ocean ecosystems are based on national activities and international agreements that vary in scope and scale and in which there are many gaps and conflicting aims (see examples, IPBES, 2019; IPCC, 2019; UN, 2021). This collectively results in varying effectiveness and resourcing of activities across the globe and often results in competition for resources between initiatives.

A key lesson from the COVID-19 pandemic is that a patchwork of *ad-hoc* activities will not provide the scientific or advisory basis required for developing and implementing appropriate response to the changes expected and their impacts on natural and human systems. Without a coherent approach to the development of plans for action, marine crises will mirror the worst aspects of the response to the pandemic: uncertain, ineffective and delayed. The COVID-19 pandemic is a wake-up call for the ocean science community.

The urgency of the challenge is clear. Already sea level, ocean temperature and acidification of the ocean are increasing, and changes to ocean ecosystems are occurring (IPCC, 2019; UN, 2021). Over the near future ocean stratification will strengthen, sea ice will reduce, oxygen will decline, and the frequency of extreme events will increase, with projected declines in net primary productivity, global biomass of marine animal communities and fisheries catch potential, with the poorest nations experiencing the greatest projected losses (e.g., Lam et al., 2016; Lotze et al., 2017; IPCC, 2019; Boyce et al., 2020). Many of these changes are irreversible even with the most ambitious implementation of mitigation measures—adaptation will therefore be crucial. Systematically improving understanding of the risks, including estimates of the potential costs of future change in the ocean through multiple processes (Narita et al., 2020), will be essential in communicating the importance of developing and implementing an action plan.

For more than two decades there have been strongly justified claims that action is required, but without a coherent global plan such calls will continue to waste resources and time in a fragmented effort. COVID-19 has highlighted to the public and governments the importance of understanding risks and the need to prepare at national and international levels and has demonstrated the crucial role science can play as part of that process. The *Action Plan for the Ocean* we propose requires coordinated international development and generation of new approaches to assessing risk and the pre-emptive provision of adaptation options for decision makers to respond to future change. New organizational structures are not required, instead effort is needed to bring together existing initiatives and bodies with free and open sharing of datasets, information, and assessment, in a trusted format. This will require engagement with a wide range of ocean science and societal stakeholders in the development, planning, support and implementation of the action plan and to ensure it becomes an embedded long-term process in ocean science and management. IMBeR aims to develop the approach and will scope opportunities to elaborate the concept and present plans at a range of forthcoming international scientific and ocean-policy meetings. The *UN Decade of Ocean Science for Sustainable Development* can provide a platform for the coordination required, acknowledging and drawing on the strengths and resources of existing research networks and communities that in some cases have taken decades to develop and evolve. Such a coordinated effort can be nimble to new challenges and operate with the willing parties as soon as possible. Without such a response, the multiple effects of ocean change will make the disparate response to the COVID-19 pandemic look relatively successful.

AUTHOR CONTRIBUTIONS

EM led the development of the manuscript. All authors contributed to the ideas and the text and approved the submitted version.

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