Will understanding the ocean lead to "the ocean we want"?

Gerald G. Singh[a,1], Harriet Harden-Davies[b], Edward H. Allison[c], Andrés M. Cisneros-Montemayor[d], Wilf Swartz[e], Katherine M. Crosman[f], and Yoshitaka Ota[f,g]

The United Nations Decade of Ocean Science for Sustainable Development (2021–2030, henceforth the Ocean Decade) aims to galvanize the international community to acquire and apply scientific knowledge of the ocean. The Ocean Decade is specifically intended to help achieve the Sustainable Development Goals (SDGs), including its promise to "leave no one behind," which includes coastal Least Developed Countries and Small Island Developing States, and will undoubtedly influence research agendas and financing well beyond 2030. This focus is captured in the phrase "the science we need for the ocean we want" (1). This first-of-its-kind UN Decade will require ambition and commitment, especially during the coronavirus disease 2019 (COVID-19) crisis.

The current draft of the Ocean Decade Implementation Plan establishes a framework of outcomes, actions, and objectives, acknowledging the need for interdisciplinary approaches to design and deliver

Researchers hoping to help deliver the "ocean we want" as a society-first principle need to understand how science can benefit ocean-dependent people. This requires a science model that co-designs and co-delivers solutions in collaboration with people whose livelihood depends on the ocean, such as the Madagascar fishers pictured here. Image credit: ©artush/123RF.com.

[a]Department of Geography, Memorial University of Newfoundland, St. John's, NL A1B 3X9, Canada; [b]Australian National Centre of Ocean Resources and Security, University of Wollongong, NSW 2522 Australia; [c]WorldFish, Jalan Batu Maung, Batu Maung, Pulau Pinang 11960, Malaysia; [d]Institute for the Oceans and Fisheries, University of British Columbia, Vancouver, BC V6T 1Z4, Canada; [e]Marine Affairs Program, Dalhousie University, Halifax, NS B3H 4R2, Canada; [f]Nippon Foundation Ocean Nexus Center, Earthlab, University of Washington, Seattle, WA 98105; and [g]School of Marine and Environmental Affairs, University of Washington, Seattle, WA 98105

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[1]To whom correspondence may be addressed. Email: geralds@mun.ca.

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solution-oriented research alongside ocean-dependent people (1). Recent proposals from the academic literature for the Ocean Decade emphasize increasing our global biophysical understanding through exploration and observation of, and experimentation on, the ocean (2–5). But will understanding the ocean lead to "the ocean we want"? We argue that proposals for the UN Decade should consider a crucial point: To achieve the ocean we want, we must better understand the needs and priorities of ocean-dependent peoples and evaluate potential solutions for them.

Science, Sustainability, and Equity

Advancements in marine scientific knowledge and technological innovation have brought myriad benefits to people and the planet. They include: understanding global environmental change; assessing effects of anthropogenic activities and ocean-derived benefits to people; understanding the structure and function of ocean ecosystems; informing decisions on environmental management; and the development of technologies that enable humans to connect with and benefit from the ocean (6–8). Yet, regardless of the intentions of researchers, science and technology can also be used, misused, or distorted in ways that have negative consequences on sustainable development as a result of political and economic motives.

Contemporary environmental degradation and social inequity result in part from the long-standing practice of applying scientific innovation to exploit natural resources in unsustainable and inequitable ways. Historically, science and technology were used to better understand ocean systems to enrich European nations by fueling mercantile and colonial interests and the geopolitical and economic demands of nations with substantive ocean estates or oceanic empires (9). Over the past century, the development of technologies to locate, extract, and store marine resources has led to large-scale pollution and habitat damage, serial overexploitation of marine species, and devastating fishery collapses (10), as well as the consolidation of catch from distant-water industrial fisheries among a small number of countries (11). Equity gaps continue to widen when developed nations are enriched at the expense of developing nations, particularly where preexisting disparities exist in the capacity to undertake, access, and use scientific research and innovation to collect and expropriate marine resources and absent appropriate mechanisms for equitable sharing of their commercial benefits (12).

Funding mechanisms can exacerbate inequity in the design, conduct, and use of scientific research and its outcomes. Investment in ocean research and development has been criticized for following developed nation priorities while neglecting locally determined priorities, and transnational financing is increasingly used as a means to promote geopolitical goals of certain nations (13). Emerging funding may also fail to reach developing nations deemed most in need—exemplified by the lack of adaptation funding for those nations whose fisheries are most vulnerable to the effects of climate change (14). Furthermore, where intellectual property regimes allow private actors to commercialize the results of basic science (e.g., the expansion of patentability from "inventions" [products] to also include "discoveries" [the knowledge behind products]), this can challenge the open science model of information sharing and accumulation of collective understanding (15).

Science does not inherently lead to sustainable or unsustainable (or equitable or unequitable) outcomes—the outcomes will depend on how, where, when, and by whom the science is designed, funded, conducted, and used. Our concern is that without an explicit consideration of "leaving no one behind," scientific research meant simply to "understand the ocean" may inadvertently contribute to unsustainable and inequitable development, with disproportionate negative outcomes for disenfranchised ocean-dependent people.

Solution-Oriented Science

Decades of research on how science contributes to innovation and policy indicates that the most successful scientific programs are solution oriented and collaborative, with policymakers, industry, and communities helping to identify science that is directly applicable to the issues they face; that is, where demand for science among end-users—the knowledge needed for decision-making—influences science supply—research priorities and outputs (16). As an example from climate science, the US Global Change Research Program aimed to provide useable knowledge for policymakers to develop mitigation and adaption plans against climate impacts, but they focused on predictive model building and understanding climate processes rather than evaluating adaptation options. As a result, this program was reportedly only able to deliver on a highly restricted set of policies to set global greenhouse gas targets and little in the way of local impact adaptation or mitigation strategy (17). Conversely, the Regional Natural Resource Management Planning for Climate Change Fund in Australia actively followed a program to reconcile science supply and demand and, as a result, was able to support nationally relevant climate projections and build capacity for climate change adaptation among decision makers (18). Solution-oriented research, based on evaluation and testing rather than only a basic understanding of ecosystems, has been identified as more effective in contributing to policy goals in the science policy literature for some time (19) and has also begun to be recognized within conservation science (20).

UN member states agreed to the SDG framework with the understanding that different national (and subnational) contexts would require context-specific planning and priorities (21), and this is also advocated in the Ocean Decade implementation plan. Ocean science for sustainable development thus needs to focus on local problems and desires in addition to global issues and approaches. The elaboration of ocean needs and societal priorities is itself a research question that would be usefully addressed during the Ocean Decade, in addition to expanding efforts to understand and map ocean processes. To ensure that

ocean research contributes to achieving the SDGs, we propose a framework for solution-oriented research whereby Ocean Decade initiatives explicitly explore the needs of ocean-dependent people, the role of science and innovation in meeting those needs, and the consequences of ocean uses for those people. We believe that this proposal is timely because ocean-dependent people, such as in Small Island Developing States and Indigenous communities, are among those projected to face significant economic and health consequences from long-term climate change, ongoing overexploitation and pollution, and emerging crises including COVID-19 (22).

Our suggested framework involves a transdisciplinary science model that front-ends social sciences and humanities and works with local knowledge holders, civil society, business, and government to co-design and co-deliver solution-oriented research as envisaged in the Ocean Decade implementation plan (Fig. 1). This framework prioritizes "no one left behind," addresses power imbalances by design, and helps realize the Ocean Decade objective of identifying ocean knowledge required for sustainable development. This framework: 1) identifies priorities and needs of ocean-dependent people; 2) understands how ocean conditions contribute to or detract from the wellbeing of ocean-dependent people, 3) proposes, designs, and implements activities and responses that aim to contribute to achieving the SDGs; and 4) evaluates and tests activities taken to promote SDGs through the acquisition and use of ocean science. Ideally, this process should provide opportunities for science policy researchers to further study the relationship between data, decisions, and outcomes and not assume that better data lead to better outcomes, as implied in an "understanding the ocean" model for the Ocean Decade.

Literature on decision making under uncertainty shows that policy is best served by science that explores and delimits uncertainty rather than only trying to reduce it (23). Our rate of understanding the ocean is unlikely to surpass both the rates at which the ocean is changing and the rate at which new scientific advances reveal new uncertainties and complexities. Complements or alternatives to prediction that should be explored in the Ocean Decade include developing state-of-the-art risk assessment (7), multi-model ensemble approaches to forecasting future oceans given uncertainty in data and model structure (24), and participatory scenario analyses to explore multiple policy pathways (25).

Our concern is that without an explicit consideration of "leaving no one behind," scientific research meant simply to "understand the ocean" may inadvertently contribute to unsustainable and inequitable development, with disproportionate negative outcomes for disenfranchised ocean-dependent people.

Further, if science programs are successful in reducing uncertainty in key natural processes, these science programs will not necessarily lead to greater certainty of effective interventions towards equitable and sustainable development. Any potential sustainability initiative would need to navigate complex and dynamic ocean systems, meaning that understanding natural environmental processes is not enough; effective sustainability initiatives need to account for

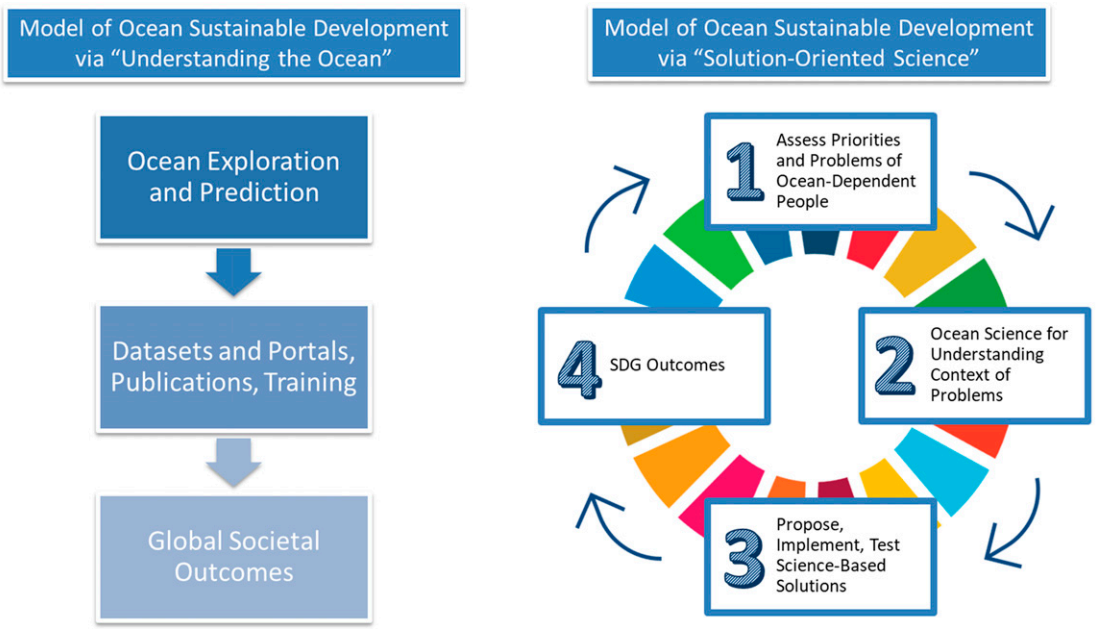

Fig. 1. We propose a solution-oriented model based on a theory of change that stipulates "knowing the ocean" will contribute to sustainable development.

social, economic, environmental, and governance dimensions simultaneously. Yet science is by design a reliable way to identify outcomes of sustainable development initiatives (19) and can better serve policy when used to evaluate policy actions already undertaken rather than when used predictively for policy making (19, 20).

Modeling Success

Existing initiatives relating to sustainable development offer an opportunity to implement a solution-oriented research framework. Globally, thousands of projects—either proposed or already underway—aim to promote marine sustainable development. They operationalize diverse theories of change, few of which have been tested. The Voluntary Commitments for ocean sustainability, made by governments, nongovernmental organizations (NGOs), the private sector, and other organizations at the first UN Ocean Conference, document a subset of these.

Beyond these ocean initiatives, we suggest that the same evaluation-research model can be used on marine science to policy programs attempting to promote sustainable development, such as the Integrated Marine Biosphere Research project, Future Earth, the Food and Agiculture Organization's Global Strategic Framework, the EU International Ocean Governance Forum, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, and the Nippon Foundation Ocean Nexus Center (of which the authors are a part). This rich portfolio of attempts at linking research to ocean-sustainable development provides a natural experiment for science to assess what kinds of research programs do (or do not) contribute to the SDGs and what underlying theories of change are more promising for future policy iterations. This model of using science to evaluate and test ocean sustainability initiatives, to refine future initiatives (with further evaluation and testing), would effectively operationalize an adaptive management research agenda at a global scale, with sub-global resolution.

As the Ocean Decade begins this year, we urge the international community to reflect on the points raised here and discuss how ocean science and "leave no one behind." Ocean Decade projects and programs can be usefully informed by the rich scholarship on the role of science in innovation and policy design and implementation and should serve to advance not only biophysical knowledge of the ocean but also how the ocean relates to people and people's desires, in all their diversity. This will require scientific priorities and questions that are explicitly solution oriented. For example, under what conditions do given institutions, policies, and programs foster human benefits from oceans and contribute to achieving the SDGs?

Finally, because uncertainty will undoubtedly be a defining, and not diminishing, aspect of research, the use of science to evaluate diverse programs operating in complex systems may offer an effective strategy to determine sustainable and equitable solutions when efforts to explain and predict the ocean may not. The development of the Ocean Decade will help determine the course of ocean science beyond the next ten years; we hope the opportunities raised here can help inform planning to ensure that ocean science can promote sustainable ocean development to ensure that no one is left behind.

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