

Co-production of knowledge and strategies to support climate resilient fisheries

Katherine E. Mills  ^{1,*}, **Derek Armitage**  ², **Jacob G. Eurich**  ^{3,4}, **Kristin M. Kleisner**  ⁵,
Gretta T. Pecl  ^{6,7} and **Kanae Tokunaga**  ¹

¹Gulf of Maine Research Institute, 350 Commercial St. Portland, ME 04101, USA

²School of Environment, Resources and Sustainability, University of Waterloo, 200 University Ave W, Waterloo, ON N2L 3G1, Canada

³Environmental Defense Fund, Santa Barbara, CA 93106, USA

⁴Marine Sciences Institute, University of California, Santa Barbara, CA 93106, USA

⁵Environmental Defense Fund, 18 Tremont St. Suite 850, Boston, MA 02108, USA

⁶Centre for Marine Socioecology, University of Tasmania, Hobart 7005, Australia

⁷Institute for Marine and Antarctic Studies, University of Tasmania, Hobart 7005, Australia

*Corresponding author: tel: +1 207 228 1657; email: kmills@gmri.org

Knowledge co-production offers a promising approach to design effective and equitable pathways to reach development goals. *Fisheries Strategies for Changing Oceans and Resilient Ecosystems by 2030* (FishSCORE), a United Nations Ocean Decade programme, will co-produce knowledge that advances solutions for climate resilient fisheries through networks and partnerships that include scientists, stakeholders, practitioners, managers, and policy experts. FishSCORE will establish (1) a global network that will develop broadly relevant information and tools to assess and operationalize climate resilience in marine fisheries and (2) local and regional partnerships that will apply those tools to identify and forward context-specific resilience strategies. FishSCORE's activities will be guided by a set of core principles that include commitments to inclusivity, equity, co-leadership, co-ownership, and reciprocity. FishSCORE will focus on identifying solutions for climate resilient fisheries, and it will also advance goals associated with capacity, power, and agency that will support iterative, pluralistic approaches to decision-making in fisheries experiencing ongoing climate-driven changes. This process of co-producing knowledge and strategies requires considerable investments of time from all partners, which is well aligned with the Ocean Decade. However, secure funding must be prioritized to support and implement co-production activities over this long time horizon.

Keywords: climate change, co-production, marine fisheries, Ocean Decade, resilience.

Introduction

Sustainable development agendas have highlighted the need for knowledge (i.e. science and other forms of information and data) that not only advances understanding of social-ecological systems, but also identifies solutions that contribute to sustainability outcomes and transformations (Colglazier, 2015; UN General Assembly, 2015; Schneider *et al.*, 2019; Norström *et al.*, 2020). Currently though, there is a large gap between available knowledge and its uptake via societal actions that slows the pace of preparedness and solutions for climate and sustainability challenges. Knowledge co-production has been offered as one approach to reduce this gap and increase application of information to societal issues (Norström *et al.*, 2020). We define knowledge co-production as an iterative, collaborative process of building partnerships that bring together multiple sources and types of knowledge to develop a systems-oriented understanding of a problem and identify potential solutions (adapted from Armitage *et al.*, 2011 and Norström *et al.*, 2020). We adopt the term 'co-production' because it is widely used in the sustainability science literature and encompasses a solution-focused component, although a variety of terms exist for similar transdisciplinary and participatory research approaches (Hakkarainen *et al.*, 2021).

Knowledge co-production is particularly relevant in the context of initiatives focused on the climate-fisheries nexus (Cooke *et al.*, 2021). Local knowledge of the coupled human

and natural elements of fishery systems can contribute real-time, place-based observations of changes at scales that are not easily observed by most periodic scientific surveys (Lima *et al.*, 2017; Ban *et al.*, 2018). Moreover, long-term perspectives gained through experience in a place can support a deep understanding of drivers, patterns, and impacts of these changes. In contrast, scientific data sets and methodologies enable place-based changes to be interpreted within a larger context, and new tools facilitate data sharing and knowledge transfer across systems. Knowledge co-production combines insights from place-based historical perspectives with inference- and model-based methods (Ban *et al.*, 2018; Zurba *et al.*, 2021). Using these jointly can help increase the understanding of change and success of adaptive actions at relevant spatial and temporal scales, which is particularly important as marine ecosystems and fisheries move into states that are outside the bounds of historical analogues (e.g. Gianelli *et al.*, 2021).

As the world strives to achieve development goals in the context of climate change, the UN Decade of Ocean Science for Sustainable Development offers an avenue for scientists and stakeholders to co-produce information and strategies that are necessary to support climate resilient fisheries. The UN Ocean Decade programme, *Fisheries Strategies for Changing Oceans and Resilient Ecosystems by 2030* (FishSCORE), will co-produce knowledge that advances solutions to support

Received: April 12, 2022. Revised: May 19, 2022. Accepted: May 20, 2022

© The Author(s) 2022. Published by Oxford University Press on behalf of International Council for the Exploration of the Sea. All rights reserved. For permissions, please e-mail: journals.permissions@oup.com

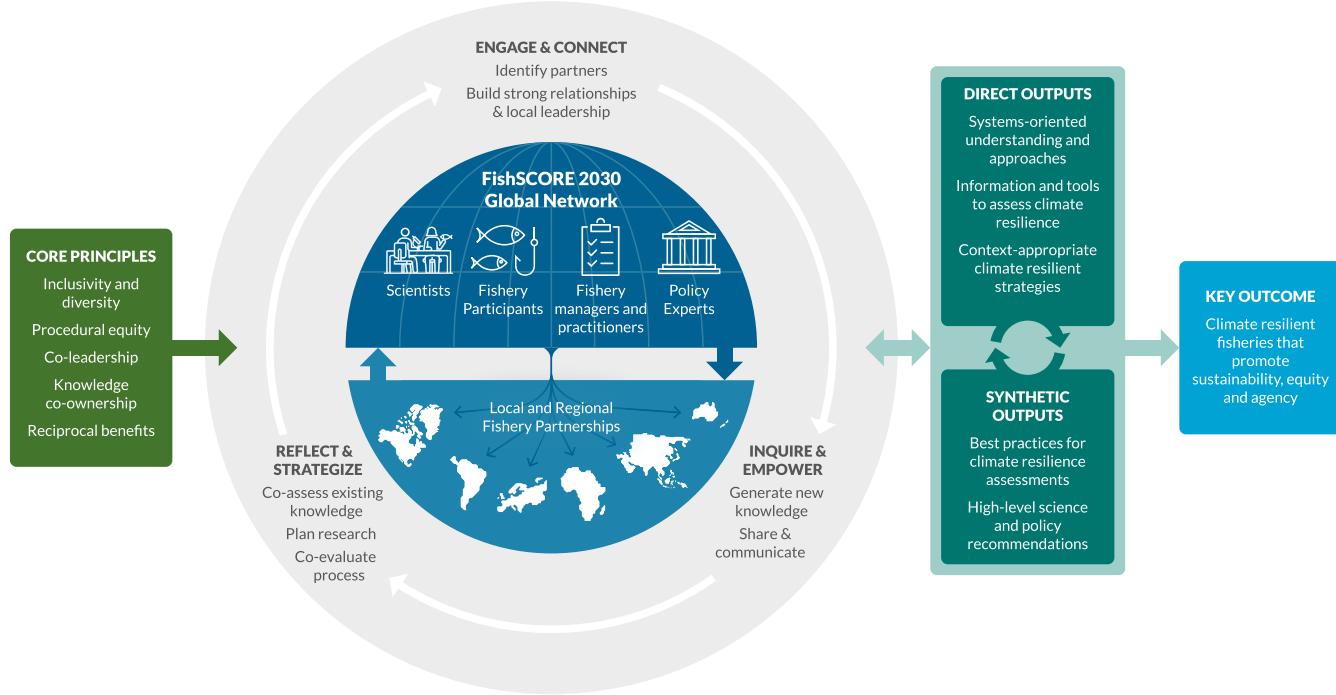


Figure 1. FishSCORE will facilitate synergies between: (1) a global network of diverse collaborators that will develop information and tools to assess climate resilience (blue box) and (2) local and regional partnerships to co-produce knowledge and solutions relevant to specific fisheries (green box). Collaborators and partners will include scientists, fishery participants (including harvesters and supply chain actors), fishery managers, fishery practitioners (including community officials, community development leaders, and non-governmental organizations), and policy experts. Co-production of knowledge and solutions will be grounded in core principles (purple box), a collective leadership model and proposed model of co-production stages (grey arrows; Caviglia-Harris *et al.*, 2021; Cooke *et al.*, 2021). Outputs from FishSCORE will emerge directly from the global network and the fishery partnerships, as well as from syntheses that span these levels (yellow boxes) and will contribute to building climate resilient fisheries that promote sustainability, equity, and agency.

healthy marine ecosystems, sustainable fisheries, and equitable distributions of benefits from a diverse set of global marine fisheries. FishSCORE will establish a network of interdisciplinary scientists, fishery stakeholders, resource managers, community practitioners, and policy makers who will:

- (1) co-produce information and tools to assess climate resilience in diverse fishery systems,
- (2) co-develop approaches and best practices to identify context-appropriate climate resilience strategies, and
- (3) support implementation of solutions to advance climate resilience in marine fisheries.

Through these efforts, FishSCORE will contribute to multiple UN Sustainable Development Goals, including development of healthy marine ecosystems and fisheries (SDG14), improvements in food security (SDG2), poverty reduction (SDG1), and advancements in human health and well-being (SDG3).

Co-production in FishSCORE

FishSCORE will apply collective and transdisciplinary leadership in partnerships between scientists and stakeholders to develop research, information, and strategies related to climate resilience in marine fisheries (Lang *et al.*, 2012; Caviglia-Harris *et al.*, 2021; Cooke *et al.*, 2021; Mason *et al.*, 2022). Although FishSCORE is currently in nascent stages of development, we plan for co-production to occur at two levels with feedback between each level (Figure 1). First, FishSCORE

will establish a global network of scientists and stakeholders representing diverse regional geographies, fishery types, sectoral roles, scientific disciplines, and policy expertise to develop broadly relevant information and tools related to climate resilience in marine fisheries. Second, regional and local fisheries partnerships will be developed in diverse fisheries—from small-scale community-based fisheries to large industrial fisheries embedded within multi-level management structures. In these cases, close collaborations will be established between scientists, policy experts, leaders, managers, and practitioners in the fishery to assess climate resilience, resilience-enhancing strategies will be identified, actionable strategies will be selected, and implementation capacity will be built. FishSCORE's co-production approach will facilitate feedback between these levels to continually improve information and tools, refine practices for applying the tools in specific fisheries, and advance science and policy recommendations that will support climate resilient fisheries.

Core principles supporting effective partnerships will be upheld across all stages and levels of co-production in FishSCORE. These include commitments to inclusivity and co-leadership opportunities for diverse participants, co-ownership of research, and reciprocity of benefits (Cooke *et al.*, 2021, originally from UK National Institute of Health Research 2018). We anticipate issues of agency, power, and equity to arise in all our partnerships and to be particularly acute in situations that involve groups that have traditionally been marginalized (Bennett *et al.*, 2021; Blythe *et al.*, 2021; Fisher *et al.*, 2022). Forefronting these core principles by selecting

partners who can commit to upholding them will foster diverse perspectives, knowledge, and values from participants. However, partners will also need to reflexively hone how the principles are upheld, given the particulars of every situation and how relationships evolve over time. For example, certain voices may need to be elevated to achieve procedural equity (Alexander *et al.*, 2022), and these may change over the duration of the partnership.

Commitments to these principles will also enable multiple modes of co-production directed towards a range of goals in different fishery systems. Chambers *et al.* (2021) identified six modes of co-production—(1) identifying solutions, (2) empowering voices, (3) brokering power, (4) reframing power, (5) navigating differences, and (6) reframing agency. We anticipate co-production partnerships developed through FishSCORE will all have goals related to solutions for climate resilient fisheries. However, these solutions-focused goals may exist in conjunction with others associated with local capacity development, shifting power relationships, and fostering agency in decision-making. Advancing broader goals that develop effective processes for navigating differences and augment power and agency of co-production partners will be increasingly important as climate change continues, given that the ongoing process of change will necessitate iterative re-evaluation and re-invention of solutions.

Our approach in FishSCORE, in terms of the core principles, collective leadership elements, and multiple goals, can be organized as a simplified theory of change (Figure 1), which serves as a benchmark for structuring programme evaluation. FishSCORE will employ both formative and summative evaluations to ensure the FishSCORE network, fishery partnerships, and the programme as a whole are progressing as intended, contributing useful products that improve climate resilience outcomes for fisheries. Participatory evaluation approaches will be used to engage a broad suite of participants in the evaluation process (NIH, 2011; Guijt, 2014). Formative evaluation will be applied to consider adherence to the principles of co-production (e.g. equity) and process of collective leadership in the global network and fishery partnerships, as well as to assess the effectiveness of feedbacks between those two levels. In the formative evaluation, we intend to incorporate opportunities to reflect on the degree to which outputs are aligned with outcomes. The outputs, outcomes, and impacts will be considered during a summative evaluation of each fishery partnership at its conclusion, although FishSCORE aspires to maintain collaborations after solutions are co-produced to ensure they continue to meet expectations (Norström *et al.*, 2020) and remain spatio-temporally relevant to climate stressors. We aim to support and guide participants to revisit solutions to ensure they remain appropriate, meaningful, respectful, and adaptable (Schwarz *et al.*, 2021). Given the anticipated long-term evolution of impacts, we will also evaluate partnerships and the FishSCORE programme as a whole at the end of the Ocean Decade.

Overcoming co-production challenges

Knowledge co-production can advance learning and understanding of a system and build capacities and agency to take action towards solutions (Djenontin and Meadow, 2018; Wyborn *et al.*, 2019). However, there are important challenges that limit the pursuit and effectiveness of co-production efforts, including those associated with historical differences in

social power among stakeholder groups and organizational cultures that privilege particular ways of knowing (Turnhout *et al.*, 2019; Cooke *et al.*, 2021; Reid *et al.*, 2021). Additionally, co-production requires an investment of time that exceeds standard scientific research processes (Cooke *et al.*, 2021). It takes considerable time to identify partners, build trust and establish good working relationships, and carry out an iterative process of applying and advancing information, synthesizing findings, and developing strategies and implementation plans. Investing this time requires resources to support partners over the duration of the collaboration. However, grant funding levels are often not able to provide sufficient time for collaborators within a single grant. Moreover, grant cycles are often short relative to the time needed for iterative science-to-action processes, particularly when outcomes and impacts of those efforts are expected to become apparent over a protracted time horizon that extends well beyond the initial intervention. The time horizon of the Ocean Decade aligns well with co-production needs if programmes can ultimately be funded at levels that support the requisite time investment and ongoing engagement of all partners.

Conclusion

Knowledge co-production offers a key approach for designing effective and equitable pathways to achieve climate resilience in fisheries. The production of knowledge is integral to building governance and management strategies that will remain effective in the face of climate change. Scaling up learnings across systems will provide valuable science and policy directions to underpin climate resilience efforts. FishSCORE will contribute to these advances at local, regional, and global levels, thereby enabling marine fisheries to support sustainable development goals, even as challenges associated with climate change increase in the coming decade and beyond.

Data availability statement

No data were generated or analysed in support of this manuscript.

Author contributions

All authors contributed to the conceptualization and design of the manuscript and co-wrote the original draft and revision, with leadership from KEM.

Conflict of interest statement

The authors have no conflicts of interest to declare.

Acknowledgements

FishSCORE, a decadal programme endorsed by the United Nations Decade of Ocean Science for Sustainable Development, was first conceptualized by a Science for Nature and People Partnership (SNAPP) Climate Resilient Fisheries Working Group. SNAPP is a partnership of The Nature Conservancy and Wildlife Conservation Society. The SNAPP working group is part of a cohort of research funded by the generosity of the David and Lucile Packard Foundation Grant #2018-68222 to address the theme of Oceans, Climate, and Equity. The authors are grateful to the working group

members and advisors for thoughtful discussion and support. We are also grateful for financial support from the Pew Marine Fellows program (to KEM), Social Sciences and Humanities Research Council of Canada through the Vulnerability to Viability (V2V) Global Partnership for Small-Scale Fisheries (to DA), and the National Science Foundation (CNH 1826668 to JGE). We thank Petri Tuohimaa for designing Figure 1. The manuscript benefited from editing and input from Meghan Fletcher and from comments provided by the editor.

References

Alexander, K. A., Fleming, A., Bax, N., Garcia, C., Jansen, J., Maxwell, K. H., Melbourne-Thomas, J. *et al.* 2022. Equity of our future oceans: practices and outcomes in marine science research. *Reviews in Fish Biology and Fisheries*, 32: 297–311.

Armitage, D., Berkes, F., Dale, A., Kocho-Schellenbergand, E., and Patton, E. 2011. Co-management and the co-production of knowledge: learning to adapt in Canada's Arctic. *Global Environmental Change*, 21: 995–1004.

Ban, N. C., Frid, A., Reid, M., Edgar, B., Shaw, D., and Siwallace, P. 2018. Incorporate indigenous perspectives for impactful research and effective management. *Nature Ecology and Evolution*, 2: 1680–1683.

Blythe, J. L., Armitage, D., Bennett, N. J., Silver, J. J., and Song, A. M. 2021. The politics of ocean governance transformations. *Frontiers in Marine Science*, 8: 634718.

Bennett, N. J., Katz, L., Yadao-Evans, W., Ahmadi, G. N., Atkinson, S., Ban, N. C., Dawson, N. M. *et al.* 2021. Advancing social equity in and through marine conservation. *Frontiers in Marine Science*, 8: 1–13.

Caviglia-Harris, J., Hodges, K. E., Helmuth, B., Bennett, E. M., Galvin, K., Krebs, M., Lips, K. *et al.* 2021. The six dimensions of collective leadership that advance sustainability objectives: rethinking what it means to be an academic leader. *Ecology and Society*, 26: 9.

Chambers, J. M., Wyborn, C., Ryan, M. E., Reid, R. S., Riechers, M., Serban, A., Bennett, N. J. *et al.* 2021. Six modes of co-production for sustainability. *Nature Sustainability*, 4: 983–996.

Colglazier, W. 2015. Sustainable development agenda: 2030. *Science*, 349: 1048–1050.

Cooke, S. J., Nguyen, V. M., Chapman, J. M., Reid, A. J., Landsman, S. J., Young, N., Hinch, S. G. *et al.* 2021. Knowledge co-production: a pathway to effective fisheries management, conservation, and governance. *Fisheries*, 46: 89–97.

Djenontin, I. N. S., and Meadow, A. M. 2018. The art of co-production of knowledge in environmental sciences and management: lessons from international practice. *Environmental Management*, 61: 885–903.

Fischer, M., Maxwell, K., Nuunoq, Pedersen, H., Greeno, D., Jingwas, N., Blair, J. G. *et al.* 2022. Empowering her guardians to nurture our Ocean's future. *Reviews in Fish Biology and Fisheries*, 32: 271–296.

Gianelli, I., Ortega, L., Pittman, J., Vasconcelow, M., and Defeo, O. 2021. Harnessing scientific and local knowledge to face climate change in small-scale fisheries. *Global Environmental Change*, 68: 102253.

Guijt, I. 2014. Participatory Approaches, Methodological Briefs: Impact Evaluation 5, UNICEF Office of Research, Florence.

Hakkarainen, V., Mäkinen-Rostedt, K., Horcea-Milcu, A., D'Amato, D., Jämsä, J., and Soini, K. 2021. Transdisciplinary research in natural resources management: towards an integrative and transformative use of co-concepts. *Sustainable Development*, 30: 309–325.

Lang, D. J., Wiek, A., Bergmann, M., Stauffacher, M., Martens, P., Moll, P., Swilling, M. *et al.* 2012. Transdisciplinary research in sustainability science: practice, principles, and challenges. *Sustainability Science*, 7: 25–43.

Lima, M. S. P., Lins Oliveira, J. E., de Nóbrega, M. F., and Lopes, P. F. M. 2017. The use of local ecological knowledge as a complementary approach to understand the temporal and spatial patterns of fishery resources distribution. *Journal of Ethnobiology and Ethnomedicine*, 13: 30.

Mason, J. G., Eurich, J. G., Lau, J. D., Battista, W., Free, C. M., Mills, K. E., Tokunaga, K. *et al.* 2022. Attributes of climate resilience in fisheries: from theory to practice. *Fish and Fisheries*, 23: 522–544.

NIH Clinical and Translational Science Awards Consortium's Community Engagement Key Function Committee. 2011. Principles of Community Engagement, 2nd edn. NIH Publication: Washington, D.C.

Norström, A. V., Cvitanovic, C., Löf, M. F., West, S., Wyborn, C., Balvanera, P., Bednarek, A. T. *et al.* 2020. Principles for knowledge co-production in sustainability research. *Nature Sustainability*, 3: 182–190.

Reid, A. J., Eckert, L. E., Lane, J. F., Young, N., Hinch, S. G., Darimont, C. T., Cooke, S. J., Ban, N. C. *et al.* 2021. "Two-eyed seeing": an indigenous framework to transform fisheries research and management. *Fish and Fisheries*, 22: 243–261.

Schneider, F., Giger, M., Harari, N., Moser, S., Oberlack, C., Providoli, I., Schmid, L. *et al.* 2019. Transdisciplinary co-production of knowledge and sustainability transformations: three generic mechanisms of impact generation. *Environmental Science and Policy*, 102: 26–35.

Schwarz, A.-M., Eriksson, H., Ramofafia, C., Masu, R., Boso, D., and Govan, H. 2021. Three-decades of research integration—transforming to collaborative aquatic food systems research partnerships in the Pacific. *Frontiers in Sustainable Food Systems*, 5: 757407.

Turnhout, E., Metze, T., Wyborn, C., Klenk, N., and Louder, E. 2019. The politics of co-production: participation, power, and transformation. *Current Opinion in Environmental Sustainability*, 42: 15–21.

UN General Assembly. 2015. Transforming our World: The 2030 Agenda for Sustainable Development A/RES/70/1: <https://www.refworld.org/docid/57b6e3e44.html> (last accessed on 11 April 2022).

Wyborn, C., Datta, A., Montana, J., Ryan, M., Leith, P., Chaffin, B., Miller, C. *et al.* 2019. Co-producing sustainability: reordering the governance of science, policy, and practice. *Annual Review of Environment and Resources*, 44: 319–346.

Zurba, M., Petriello, M. A., Madge, C., McCarney, P., Bishop, B., McBeth, S., Denniston, M. *et al.* 2021. Learning from knowledge co-production research and practice in the twenty-first century: global lessons and what they mean for collaborative research in Nunavut. *Sustainability Science*, 17: 449–467.