ESSAY

Reflections on Breaking Down Silos in Fisheries Science

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INTRODUCTION

In 2023, I've been deeply honored to receive recognition for my modest contributions to advancing the cause of utilizing economics in the sustainable management of environmental resources, particularly for the benefit of future generations and our most vulnerable communities. The year commenced with the humbling acknowledgment of being named a corecipient of the prestigious 2023 Tyler Prize for Environmental Achievement (https://tylerprize.org), culminating with the esteemed accolade of receiving the Prince Albert 1 Grand Medal for Science (https://www.oceano.org/en/) and named one of 100 most influential Africans of 2023 (https://100.newafricanmagazine.com)!

During the 2023 Tyler Prize Award Ceremony held in Los Angeles in April, Margaret Catley-Carlson, a member of the Tyler Prize Selection Committee, was tasked with elucidating the reasons behind my selection as a corecipient alongside my esteemed colleague and longtime collaborator, Daniel Pauly. Margaret's insightful remarks during the ceremony resonate profoundly, offering valuable insights that I believe hold significant merit for readers, particularly early career scholars navigating their professional trajectories. The potency of Margaret's comments inspired this contribution, and I extend my heartfelt gratitude to Margaret for her invaluable guidance and support—thank you immensely, Margaret!

This essay is structured around the five compelling reasons discussed by Margaret.

MARGARET CATLEY-CARLSON'S FIVE REASONS

One, both of these gentlemen [Pauly and Sumaila] come from Vancouver, British Columbia, Canada, I also come from Vancouver, British Columbia, Canada so I wish to express the pride in very worthwhile citizens and to be quite proud about it so that's my first reason for feeling extremely happy about this.

Two, Rashid represents an essential approach the planet needs to solve most of our problems moving from a silo to the larger place. I've been making speeches on a great number of issues on water, on food production, all sorts of questions, and one of the major obstacles is exactly this; and at the end of my slide deck I always have a picture of silos, and I talk about the need, the joy of what the 20th century brought us, which was improved science in a lot of silos. But what it didn't do was learn how to start opening those silos, and moving knowledge and moving the faith and the concern from one to the other. And he [Rashid] is the epitome of the recognition about the importance of breaking through the silos. Whoever thought that an economist would become a bio-environmentalist; somebody who can become a biologist and a fishery expert at the same time is really quite extraordinary, so this is a very important part and this needs to spread contagiously across the world of scientists to move out of "The Silo" approach into the approach that joins up the knowledge that we have.

Three, Rashid has created and disseminated data, information and insights based on the science… but he goes beyond science, and he's not afraid to speak about morality; about what is good, what is bad, what is right, what is wrong. Not all scientists do that—in fact, I've met many scientists in my life who say, "Well it's up to me to set the facts on paper and it's up to you as the reader to decide whether this is good or bad." Well, that's exactly how we got to the place that we're in as just described, with being fearful of saying "this is not good," "this is very bad," and this scientist—this person—absolutely does not hesitate to do this.

Four, he talks about: Subsidy. Very few people ever talk about subsidy, and the actual evil that it brings; not just to fishing… To all sorts of things; to agriculture, to water use, fresh water use, a field I'm particularly interested in. But he has talked, and he's done the math, and he's done the science about what subsidy can actually do, and he points out that subsidy is just one more way the rich countries have it over poor countries because they can afford to offer more financial assistance to their fishers, to their factories, all the rest of it. So, he comes out and talks about subsidy. Very few, especially natural scientists, would ever talk about subsidy, not only does he study subsidy, he talks about it, he talks about it in mathematical and economic terms.

Five, he focuses on one of the truly serious issues on the planet and that's the lack of international jurisdiction in areas where international jurisdiction is so much needed, and environmentalists are coming to better understandings of the need, the fact, that we need to talk about this; but we need to understand that the absence of jurisdiction on things like the high seas mean that in an area in which there's no national jurisdiction if we don't really pay attention there we're going to be in deep trouble because the outcome of the lack of jurisdiction will simply move into all of our areas of issues.

Margaret Catley-Carlson astutely identified crucial aspects of my life's work. Reflecting on her insights:

- Margaret's acknowledgment of the imperative to transcend disciplinary boundaries (point two) resonates deeply. My career has been a testament to this ethos, advocating for interdisciplinary collaboration to confront multifaceted environmental challenges. I will return to this point later in this article.
- Her recognition of ethical engagement (point three) aligns profoundly with my conviction that scientists bear a responsibility not only for facts but also for ethical considerations in their research and communication.
- Regarding subsidies, as highlighted by Margaret (point four), my work has extensively delved into understand-

DOI: 10.1002/fsh.11076

ing and dissecting their environmental as well as socioeconomic impacts. Addressing these implications has been a focal point of my research.
- Lastly, Margaret's emphasis on global jurisdiction, notably in areas like the high seas, echoes my advocacy for international cooperation and governance to protect critical resources beyond national boundaries—after all, fish don't need visa to cross boundaries!

Each of Margaret's points deeply resonates with my lifelong endeavors, emphasizing the urgency of interdisciplinary collaboration, ethical responsibility, economic analysis, and global stewardship in the realm of environmental conservation.

BREAKING THE SILOS

The ocean acts as a crucial testing ground, vividly showcasing the urgent need to dissolve scientific barriers and nurture interconnectedness. When we interact with the ocean, our actions boil down to two primary aspects. Firstly, we "take" resources like fish, intricately weaving them into our economy, culture, and societal fabric (Sumaila et al. 2012). Secondly, our endeavors generate waste, often finding their way into the ocean and the broader environment (Abbott and Sumaila 2019; Lau et al. 2020). Humanity faces a pressing dilemma—balancing responsible resource extraction while staunchly preventing pollution.

No single discipline or isolated approach offers a comprehensive solution. Instead, the crux lies in interdisciplinary collaboration, integration, partnership, and the collective cultivation of knowledge. We need natural scientists who are adept in oceanic physics, chemistry, biophysics, and ecology. Concurrently, social scientists well-versed in diverse human dimensions—ranging from economics and sociology to anthropology, law, and philosophy—hold equal significance. This fusion of expertise stands as a linchpin to grasp the delicate equilibrium between harnessing ocean resources and preserving its intricate ecosystem. Only through a convergence of varied knowledge and perspectives can we navigate the ocean's intricate challenges, ensuring its enduring sustainability for future generations (Frazão Santos et al. 2023).

Recognizing the critical necessity of breaking down knowledge silos has propelled me into the realm of interdisciplinary oceans and fisheries economics. My aim has been to fuse economics with diverse disciplines, ensuring sustainable management of ocean resources across generations—an endeavor encapsulated in the concept of "Infinity Fish," "Infinity Ocean," and "Infinity Biodiversity" (Sumaila 2021).

Leading several interdisciplinary, multi-institutional research endeavors has yielded pivotal insights, data, and models crucial to fisheries economics and ecosystem management (e.g., Lam et al. 2011, 2020; Sumaila 2013). Collaborative efforts involving my partners, postdoctoral researchers, and students have significantly contributed to shaping improved policies for coastal communities' well-being and sustainability (Bennett et al. 2019). Moreover, considerable dedication has been invested in training ocean governance professionals worldwide (Andrews et al. 2020).

My interdisciplinary approach has steered me towards integrated bioeconomics (Sumaila et al. 2019), marine ecosystem valuation (Sumaila 2004), and the in-depth analysis of global issues, such as fisheries subsidies (Sumaila et al. 2021), illegal and unreported fishing (Sumaila et al. 2020), alongside the economics of high and deep seas fisheries (Sumaila et al. 2007, 2010, 2015). Establishing collaborative partnerships with scientists and experts globally has granted me the privilege of engaging in fisheries and natural resource projects spanning diverse regions: from Norway, Canada, and the North Atlantic, to Namibia and southern Africa, Ghana, Nigeria and West Africa, Brazil and South America, and Hong Kong and the South China Sea.

THE OceanCanada PARTNERSHIP: A BREAKING THE SILOS EXAMPLE

Most recently, I served as Project Director of the OceanCanada Partnership (OCP; https://oceancanada.org), which took root in 2014, driven by a resolute commitment to fostering resilient and sustainable oceans along Canada's three diverse coasts. It stands as a robust 7-year initiative, generously supported by the Social Sciences and Humanities Research Council of Canada. Our consortium, comprising 22 formal research partners spanning universities nationwide, community organizations, and Fisheries and Oceans Canada, is dedicated to comprehending and mitigating threats confronting Canada's Arctic, Atlantic, and Pacific oceans, while also envisioning a shared trajectory for their future.

At the heart of the OCP's mission lies a collective aspiration to harmonize the well-being of coastal communities and the marine environment (Sumaila et al. 2024a). Our interdisciplinary approach, drawing expertise from diverse realms such as economics, law, geography, ethics, fisheries science, and oceanography, intertwines with local and Indigenous knowledge (e.g., Jones et al. 2024a). This amalgamation serves as a foundation to inform regional and national policies, attuned to the needs of communities.

Our research amalgamates social, cultural, economic, and environmental insights, culminating in a national repository of knowledge concerning oceans and coasts. Over our project's tenure and beyond, we engage in an ongoing assessment of Canada's three oceans, crafting prospective scenarios for the future of our coastal regions. Simultaneously, we nurture a national dialogue, coalescing into a shared vision that encapsulates the essence of Canada's oceans (Bailey et al. 2016).

The paramount concern of our team revolves around the vitality of communities tied to the Pacific, Atlantic, and Arctic oceans, safeguarding their livelihoods and cultural heritage. Within our research, three pivotal cross-cutting themes have emerged: "Changing Oceans," "Access to Ocean Resources," and "Ocean Governance." These themes encapsulate the depth and breadth of our collective efforts towards advancing the sustainability and resilience of Canada's invaluable marine ecosystems (Sumaila and the OCP team 2024). Specific research questions guiding the OCP include: (1) how do changing oceans affect access to resources and governance? (2) how do social, economic, and governance responses to changing oceans impact ocean sustainability and coastal well-being? In responding to these questions, our goal is to produce data, knowledge, insights that would be useful to scholars and policymakers, as well as students of ocean science, fisheries, economics, and management.

The central guiding principle of the OCP is that developing effective policies for Canada's oceans and coasts necessitates an integrated perspective that aligns researchers, industry stakeholders, Indigenous communities, and the public in understanding emerging challenges and opportunities. It's imperative for Canada to anticipate future impacts, particularly those stemming from climate change, on our marine

resources, as these directly influence livelihoods, communities, and crucial economic sectors.

The complexity of Canada's oceans and coasts is akin to intricate social–ecological systems (SESs), presenting multifaceted research, management, and policy challenges (Berkes et al. 2003). Viewing these systems through an SES lens underscores their dynamic, interdependent nature—emphasizing the interaction between social and ecological processes (Ostrom 2009).

Illustrated in Figure 1, Canada's ocean–coastal SESs exist within a national system, composed of three distinct subsystems—the Arctic, Atlantic, and Pacific. Each regional SES holds unique cultural, historical, socio-economic, and biophysical characteristics, converging through national policies, regional implementation, and knowledge exchange. The dynamics of these SESs are shaped by global, national, and regional drivers, including climate change, resource accessibility, and governance shifts across various scales. Simultaneously, the SES dynamics also influence these drivers.

The OceanCanada Partnership framework explores the interconnections between these drivers and Canada's SESs. The future trajectories of these SESs hinge upon their diverse responses to drivers, moderated by national and regional policies and knowledge exchanges.

In exploring potential trajectories for Canada's oceans and coasts, the OCP arrived at these three insights. Firstly, the fate of Canada's oceans and coasts is intricately entwined with the imperative journey towards Indigenous reconciliation, particularly in addressing climate change, governance, and economic access (Jones et al. 2024a). This calls for comprehensive considerations across scales, acknowledging the enduring impacts of colonization on Indigenous communities—dispossession from land, ocean territories, and marine resources, resulting in ongoing social, cultural, and economic ramifications. Overcoming obstacles to reconciliation involves navigating diverse federal, provincial, and territorial jurisdictions, diverse Indigenous populations, and resistance to power sharing (Jones et al. 2024b). Though some positive strides in co-governance have emerged, substantive progress in rectifying dispossession remains limited. Achieving ecologically sustainable and socially just outcomes will necessitate equitable engagement of Indigenous communities in envisioning and planning ocean spaces, emphasizing respect for Indigenous knowledge, equitable co-management arrangements, and fostering relationships to support Indigenous self-determination.

Secondly, fostering opportunities for emerging scholars and youth is paramount. The OceanCanada Partnership has provided a platform for senior and junior scholars, students, and nonacademic members to engage in interdisciplinary, problem-driven research at various scales. With over 63 students and postdoctoral fellows trained, the program remains committed to equipping them with the necessary skills, knowledge, networks, and partnerships to drive forward research within Canada and globally.

A third critical insight underscores the need to balance project execution with a respect for emergent properties. Long-term science partnerships such as the OCP require clear articulation of objectives, deliverables, and hypotheses upfront while acknowledging that these formulations evolve during research execution. Despite an initial regional compartmentalization, the OCP reflects an emergence of three cross-cutting themes, fostering integration across disciplines, geographies, and academia–practitioner interfaces.

The OceanCanada Partnership has been amazingly productive, leading a top American scholar to state that our, "List of outputs is dizzying, to say the least!" Outputs from the OCP include the following:

- Over 500 publications;
- over 500 presentations, meetings, and workshops;
- 16 books and volumes;

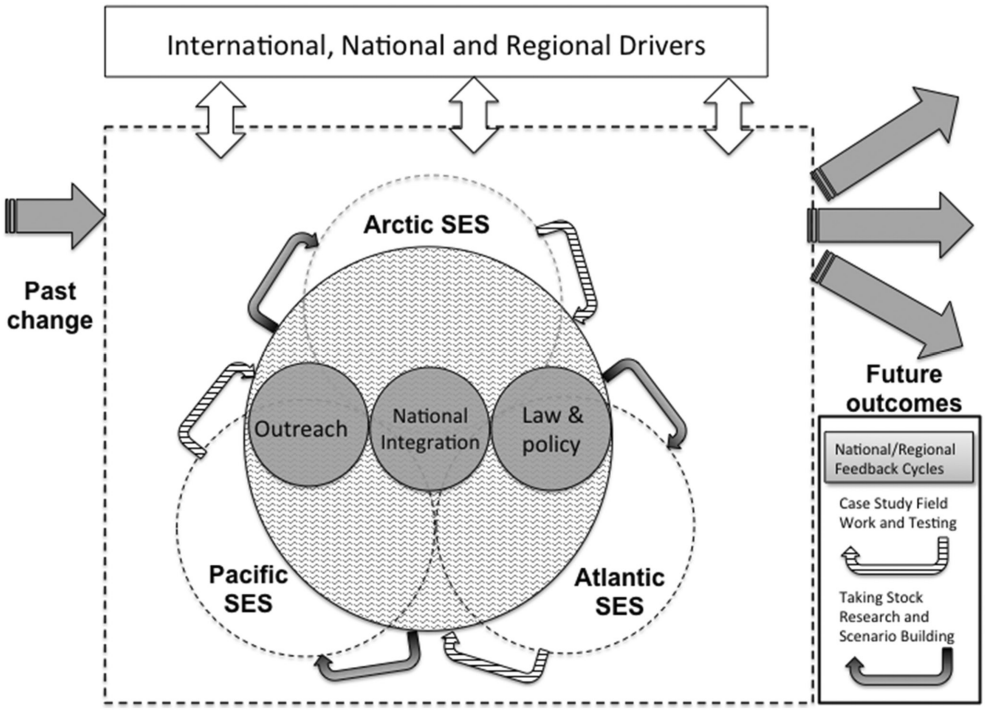

Figure 1. Conceptual framework of OceanCanada representing the ocean–coastal social–ecological system of Canada. Source: Sumaila et al. (2024a).

- 50+ films, documentaries, and videos; and
- at least 63 graduate students and postdoctoral fellows trained.

A key product of OCP is a Book entitled *Sea Change: Charting a Sustainable Future for Oceans in Canada* (Sumaila et al. 2024b). This book provides a capstone synthesis of diverse research by the OCP that addresses the current issues and challenges related to the future of Canada's oceans and coastal communities in an interdisciplinary partnership.

In conclusion, despite our current trend of overexploiting ocean resources and polluting our waters, the concept of "Vanishing fish" (Pauly 2019) is not an inevitable fate. The idea of "Infinity Fish," wherein with wise management, fish can continually provide benefits (Sumaila 2021), remains viable. However, realizing these infinite benefits necessitates abandoning the belief that we must extract everything from everywhere all at once.

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