International Science Council

The global voice for science

June 2025

council.science

POLICY BRIEF:

CO-PRODUCING OCEAN ACTIONABLE KNOWLEDGE FOR TRANSFORMATIVE SOLUTIONS AND GLOBAL COOPERATION

Authors: Peter Haugan (co-chair), Lynne Shannon (co-chair), Kwame Adu Agyekum, Maritza Cárdenas, Valérie Masson-Delmotte, Michelle Mycoo, Ilka Peeken, Fangli Qiao, Awnesh Singh, Sabrina Speich, Mia Strand, Rashid Sumaila

Reviewers: Marie Alexandrine Sicre, Laura Pereira, Maria del Pilar Cornejo de Grunauer, Emily Twigg

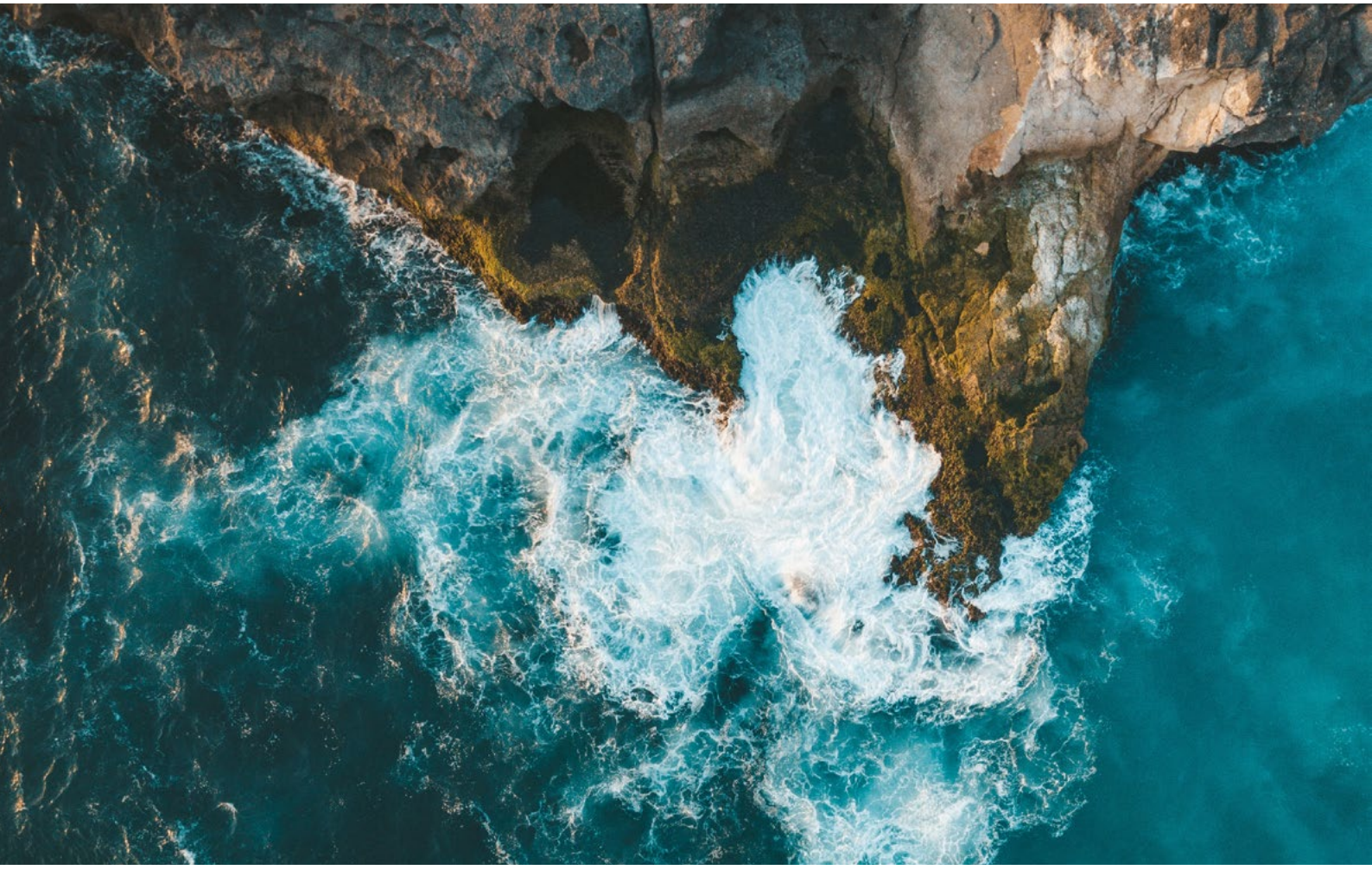
ISC Secretariat coordination: Anda Popovici, Anne-Sophie Stevance, Apolonia Drábová, James Waddell

INTRODUCTION

The ocean provides vital opportunities for sustainable development, and can be a catalyst for cooperation that transcends geopolitical tensions. As a global commons, the ocean is essential not only for climate regulation, renewable energy, food security, human wellbeing, livelihoods and cultural heritage, but also for geopolitical stability and international collaboration. Sustaining these services requires integrated, science-based approaches that bridge actors, sectors and disciplines – recognizing the ocean's ability to deliver co-benefits through transformative solutions that address multiple sustainability challenges.

This policy brief promotes integrated and transdisciplinary science to deliver actionable knowledge on conserving and sustainably managing marine resources. It showcases how collaborative science-driven approaches can address multiple priorities, environmental degradation, resource competition and asymmetries in governance. Drawing on best-practice examples at different scales, the brief illustrates how co-produced science can drive holistic solutions, cross-sectoral collaboration and ocean science diplomacy.

Photo: Freepik



KEY MESSAGES

1

The ocean faces escalating threats from a multitude of co-occurring and interacting stressors, pushing it towards critical tipping points. Through the degradation of marine ecosystems, these threats could trigger irreversible changes undermining Earth's stability, with cascading impacts for global climate, food security, social equity and human wellbeing. As these pressures intensify, they demand urgent action to prevent further degradation of the ocean and its critical role in maintaining planetary stability.

2

Safeguarding ocean resilience offers a unique opportunity to generate co-benefits that address multiple global challenges including climate change, biodiversity loss, pollution and poverty. Strengthening ocean health is therefore integral to advancing sustainable development, improving social equity and enhancing community wellbeing worldwide.

3

Effective governance and sustainable management require integrated, science-based approaches that bridge disciplines, sectors and actors. Within these approaches, transdisciplinary, participatory research drawing from diverse knowledge systems – including local and Indigenous knowledge – is essential for fostering collaboration and innovation, and delivering positive and synergistic ocean health that supports societal needs

4

Protecting the ocean is a strategic imperative for promoting global peace and cooperation. Science can provide a platform for building trust and diplomacy, and addressing inequalities in access to knowledge, capacity and decision-making. Collaborative science in particular can foster mutual understanding, reduce tensions, and support fair and equitable participation for inclusive ocean governance.

5

Securing the ocean's role as a foundation for human wellbeing and planetary stability requires urgent, coordinated action. In ensuring such action is effective, strategic investments in scientific capacity, technology transfer, and the sharing of data and knowledge are crucial – especially in the context of a fragmented geopolitical landscape with leadership and funding vacuums.

I. OCEAN AT A TIPPING POINT OR TURNING POINT?

The ocean plays a vital role in sustaining planetary resilience, having absorbed most of Earth's excess heat and roughly 30 percent of anthropogenic carbon dioxide (Gruber et al., 2019). However, this buffering capacity may become diminished, placing increased stress on marine life living under changing conditions.

A myriad of co-occurring and interacting stressors threatens marine ecosystems. These range from overfishing, pollution, ocean warming, acidification and deoxygenation to extreme ocean and climate events and emerging activities like deep-sea mining. Microplastics and nanoplastics now occur worldwide – from deep-sea sediments to marine organisms at every trophic level – potentially disrupting carbon cycling and the ability of the ocean to mitigate climate change (International Science Council, 2023).

An estimated 60 percent of global marine ecosystems are already degraded or used unsustainably (Buonocore et al., 2021). Stressors are pushing the ocean towards multiple tipping points, both biophysical – such as potential disruptions to ocean circulation (Boers, 2021) – and socio-ecological – where degradation threatens coastal livelihoods, human wellbeing and the provision of ecosystem services (Intergovernmental Science–Policy Platform on Biodiversity and Ecosystem Services, 2019). These changes have the potential to exacerbate climate change in ways that are increasingly difficult to project, and to trigger abrupt and potentially irreversible shifts (Armstrong et al., 2022).

The degradation of marine systems is driving increasingly severe and uneven socio-economic impacts, particularly for coastal and Indigenous communities. These groups maintain deep cultural, spiritual and economic ties with the ocean, whilst being the least responsible for its degradation. Their food security, livelihoods and sovereignty are already threatened by intensifying ocean-related extremes and climate-induced shifts in fish stocks, sea-level rise and biodiversity loss (Bindoff et al., 2019). Such impacts compound existing inequities, placing socially vulnerable populations at even greater risk (U.S. Environmental Protection Agency, n.d.).

These wide-reaching impacts highlight that ocean degradation is not merely a localized environmental issue, but a global threat to sustainable development and the achievement of shared societal goals. As

Photo: Canva

a global commons, the ocean underpins climate regulation, cultural heritage, renewable energy, food and nutritional security, and overall human wellbeing, and is therefore deeply interconnected with nearly every major global challenge. This means that changes in marine ecosystems – from alterations to ocean temperature and salinity to declining fish stocks or increased pollution – have cascading effects on other systems[1].

However, this moment of global crisis also presents an opportunity. Strategic, coordinated investments to safeguard, sustainably manage and build the resilience of ocean systems can generate significant co-benefits to address multiple global challenges – from food security, ocean hazard prevention and mitigation, and biodiversity conservation to health and equity improvements and global stability. Integrated, science-based approaches and solutions bridging disciplines, sectors and knowledge systems can help deliver such outcomes.

INTEGRATED APPROACHES FOR SUSTAINABLE OCEAN ACTION

Creating policy frameworks to leverage co-benefits and address trade-offs

As the ocean faces growing threats to its ability to provide essential ecosystem services, efforts to ensure its protection and restoration must form a foundation for broader sustainable development. These efforts require an integrated perspective that improves our knowledge on, and accounts for the ocean's role in, climate regulation, food and water systems, public health, and social and environmental justice.

They also rely on multi-stakeholder and multi-scale collaboration to create a deeper understanding of relevant issues and context-specific solutions, support inclusive governance and community wellbeing, and enhance the capacity of scientists and stakeholders.

The OceanCanada Partnership (Case Study 1) is a prime example of such an integrated approach in action.

CASE STUDY 1:
Advancing integrated approaches for sustainable ocean governance through the *OceanCanada* Partnership

Author: Rashid Sumaila, Institute for the Oceans and Fisheries and School of Public Policy and Global Affairs, University of British Colombia, Canada

Geographical scope: Canada-wide (Arctic, Atlantic and Pacific coasts)

Canada, with the world's longest coastline and diverse coastal communities, faces significant challenges from climate change (Lam et al., 2021), overfishing, habitat degradation, pollution and fragmented policies (Sumaila et al., 2024). In response, the *OceanCanada* Partnership (2014–2022), established a national research network to advance knowledge and capacity for sustainable ocean governance across Canada's Pacific, Atlantic and Arctic coasts[2].

Bringing together more than 100 researchers from over 15 institutions, alongside Indigenous communities, non-governmental organizations, government, industry and local actors, the initiative championed an interdisciplinary and co-produced approach. This approach integrated natural sciences, social sciences, humanities and Indigenous knowledge systems across six working groups: Fisheries, Marine Spatial Planning, Law and Policy, Community Wellbeing, Ocean Data and Climate Change, and Knowledge Mobilization.

Key actions included baseline assessments of ocean health and community wellbeing, development of frameworks to track socio-ecological resilience, creation of tools like the *OceanCanada* Data Portal, and support for Indigenous-led ocean planning and capacity building (Harper et al., 2018). Canada's incoming administration adopted policy recommendations put forward by *OceanCanada* researchers (Bailey et al., 2016), aligning national ocean policy with scientific evidence.

[1] *See the ISC high-level briefing on science-based priorities for UNOC-3: Ocean at a tipping point: Science-based priorities for UNOC-3.*
[2] *See https://oceancanada.org/.*

These recommendations involved:

1. Full implementation of the Oceans Act by establishing Marine Protected Areas meeting global commitments
2. Stronger protection for endangered marine species under the Species at Risk Act
3. Restoration of habitat protections under the Fisheries Act
4. Adoption of a scientific integrity policy allowing federal scientists to share their research openly.

Internationally, *OceanCanada's* work on fisheries subsidies, climate change and high seas governance shaped activities of the Intergovernmental Panel on Climate Change, the Intergovernmental Science–Policy Platform on Biodiversity and Ecosystem Services, the World Trade Organization, the World Bank and the United Nations. The partnership also produced more than 440 publications and policy briefs, influenced Canada's Blue Economy Strategy and marine spatial planning processes, and contributed to training a new generation of interdisciplinary ocean researchers (Bennett et al., 2019).

This case study demonstrates that delivering effective and integrated ocean governance depends on grounding science priorities and policy in local realities, making data accessible, investing in people – especially Indigenous and early-career researchers – embracing interdisciplinarity, and building partnerships based on trust and respect for diverse knowledge systems.

Despite increasing scientific evidence demonstrating the benefits of integrated approaches to sustainability challenges (Lah, 2025; Lund et al., 2011), ocean governance and decision-making remain largely fragmented, failing to adequately address the complexity of marine socio-ecological systems and the growing pressures they face. In this regard, efforts to advance ocean sustainability often encounter conflicting objectives across policy domains, where measures aimed to achieve one goal may inadvertently undermine progress in another.

For example, large-scale offshore renewable energy projects are critical for decarbonization and advancing progress on climate goals; however, these developments can disrupt marine habitats and migratory species if not moderated through careful planning and consultation (Pelc and Fujita, 2002). Such overlapping pressures and potential for trade-offs illustrate the urgent need for integrated, cross-scale and cross-sectoral approaches to ocean governance – supported by robust science–policy–society interfaces at all levels of governance, and co-produced, participatory approaches to science. A coral restoration project led by Fragments of Hope (Case Study 2) demonstrates how such an approach can help build community ownership, drive ecosystem restoration, revitalize local economies, and foster collaboration and shared learning across regions.

CASE STUDY 2:
Restoring coral reefs and providing development co-benefits through Fragments of Hope

Author: Michelle Mycoo, The University of the West Indies, Trinidad and Tobago

Geographical scope: Laughing Bird Caye National Park near Placencia Peninsula, Belize

Coral reefs are vital to Caribbean ecosystems and livelihoods, supporting fisheries, tourism, coastal protection, medical innovation and cultural heritage. Yet, they face mounting threats from climate change, plastic pollution, influxes of the seaweed *Sargassum*, and unsustainable fisheries and tourism.

In Belize, the not-for-profit organization Fragments of Hope leads community-based coral restoration in Laughing Bird Caye National Park (LBCNP), which generates USD 5 million per annum (Nawaz et al., 2017), and other sites. Working with local fishers, tour guides and government agencies, the project has re-seeded the devastated reefs with genetically robust, diverse and resilient corals, enabling research on coral bleaching and improving reef recovery. Its multi-stakeholder participation has been critical to building community ownership and strengthening local expertise on restoration.

Since the launch of Fragments of Hope, more than 82,000 nursery-grown coral fragments have been outplanted in LBCNP. Of these, elkhorn coral has survived over nine years, and nursery-grown corals over six years – the longest documented survival period in the Caribbean – with an 89 percent survival rate after 13 years. Many outplanted corals have successfully reproduced, helping restore LBCNP as a vibrant tourism site with abundant marine life.

Fragments of Hope fosters regional cooperation, through exchanges, training and shared learning across the Caribbean. A 2016 workshop in Jamaica conducted by the project with the University of the West Indies expanded coral restoration know-how, and as of 2022, trained more than 90 Belizeans. In 2024, efforts shifted to the identification of corals and monitoring of bleaching in response to intensifying climate impacts, with more than 30 Belizeans trained.

The case study demonstrates the value of a multi-stakeholder approach in building local support and shaping relevant policy. Through regional collaboration and knowledge sharing, the project has expanded its impact and strengthened collective capacity to address shared challenges.

It also shows how applying science-based marine restoration can deliver cross-sector benefits, such as revitalizing tourism and fisheries, that align with United Nations Sustainable Development Goals. Finally, it demonstrates adaptative strategies in real time to ever-shifting climate realities.

Enabling co-production, equity and public engagement in ocean science

Scientific research, encompassing natural and social sciences, and humanities – as well as interdisciplinary and transdisciplinary approaches that bridge diverse knowledge systems – is crucial in the transformation towards sustainable governance of the ocean. It identifies and addresses systemic risks, supports early-warning efforts and capacity building, and informs inclusive policy frameworks.

However, science remains underutilized, particularly in a context marked by increasing geopolitical tensions and competition over limited marine resources. The persistent disconnect between science, policy and society continues to limit the uptake of science in decision-making and community-level action. Bridging this gap is therefore essential for more coherent and inclusive ocean governance.

Photo: Canva

Practical tools such as the Coastal city Ocean-bAsed Solution Toolkit for sustainable development (COAST)[3] can support decision-makers and the public in accessing, understanding and applying scientific research to real-life problems.

More importantly, a fundamental shift is needed in the way ocean science is conducted – moving beyond extractive research models and existing power asymmetries towards more solutions-oriented, inclusive approaches that bridge science, policy and society (Pendleton et al., 2023; van Noort, 2025). In this regard, research should be transdisciplinary and co-produced, responding to the complexity of challenges relating to marine socio-ecological systems and sustainability.

Such a shift requires the meaningful inclusion and participation of diverse actors, including policy-makers, scientists, Indigenous and local knowledge holders, marginalized voices and civil society – at every stage of the research process – so that decision-making processes are more inclusive, integrated and just. Additionally, it demands that structural inequalities in ocean science, including existing disparities in funding, infrastructure and capacities, are addressed – and that institutional support for transdisciplinary approaches is ensured through revised funding practices, evaluation criteria and assessment metrics (Kaiser and Gluckman, 2025; Österblom et al., 2020).

[3] See COAST toolkit.

A co-produced approach to science provides a foundation for more inclusive and adaptive sustainability efforts, and ensures that the benefits of ocean governance are equitably distributed, fostering shared responsibility, ownership and custodianship of ocean resources (Caldeira et al., 2025). For example, a regional research initiative in the Pacific oceanic region (Case Study 3) signifies a landmark synthesis of scientific, Indigenous and community-based knowledge that redefines how climate change is understood, experienced and addressed. This process can be facilitated by knowledge brokers and boundary organizations, such as regional science-policy platforms or transdisciplinary networks that connect

CASE STUDY 3:
Engaging voices of the Pacific to deliver climate resilience

Author: Steven Ratuva, the University of Canterbury, New Zealand; Awnesh Singh, University of the South Pacific, Fiji

Geographical scope: Southwest Pacific

The Pacific Islands, bound together by the vast expanse of the world's largest ocean, are on the frontline of the climate crisis. Amid this existential threat, the region's peoples – descendants of voyagers, oceanic navigators and coastal settlers

Photo: Canva

– are drawing on centuries of cultural ingenuity and ecological knowledge to forge locally rooted responses. Across some of the smallest and most environmentally vulnerable nations on Earth, Pacific communities are developing adaptive strategies that blend Indigenous wisdom with contemporary science.

The Pacific Ocean and Climate Crisis Assessment regional research initiative captures the deep interconnection between Pacific Islanders and the ocean, which serves not only as a life source but also as a space of identity, innovation and resilience. Bringing together an unprecedented network of Pacific scholars across disciplines such as oceanography, meteorology, environmental studies, Indigenous knowledge systems and social sciences, the work provides a comprehensive, community-grounded understanding of climate change in the Pacific.

Through empirical fieldwork, cross-cultural integration of knowledge and engagement with grassroots voices, this body of research sheds light on how the ocean both shapes and supports Pacific responses to climate disruption. It also contributes vital insights to regional policy, education and global climate narratives, demonstrating that sustainable futures for Pacific nations must be ocean-centred, culturally grounded and driven by the lived realities of those who call these waters home.

Democratizing ocean science is another vital step towards strengthening its role in society (see Kelly et al., 2023a, 2023b; Worm et al., 2021). Citizen empowerment, public engagement and science literacy, particularly among youth and coastal populations, can help counter disinformation and misinformation, foster societal understanding of ocean challenges, and promote more participatory and accountable decision-making.

Such broad public engagement also supports more inclusive approaches to data collection, where greater involvement of industry and local communities generates more relevant, context-specific data. This, in turn, can strengthen scientific models and support better ocean management, including by filling critical knowledge and data gaps. For example, an initiative monitoring the toxic alga *Ostreopsis* (Case Study 4) highlights how public engagement, citizen science and accessible tools can enhance early-warning systems and generate locally relevant data to address emerging threats to ocean health.

CASE STUDY 4:
Engaging the public and employing citizen science to monitor Ostreopsis and protect human health

Author: Elisa Berdalet and Magda Vila, Institute of Marine Sciences, Spain; Rodolphe Lemée and Eva Ternon, Sorbonne University, France; Stefano Accoroni and Cecilia Totti, Polytechnic University of Marche, Italy; Valentina Asnaghi and Mariachiara Chiantore, University of Genoa, Italy; Patrizia Borrello and Emanuela Spada, Italian Institute for Environmental Protection and Research, Italy; Florent Champion and Clara Fricano, Secretariat of the RAMOGE Agreement, Monaco; Marie-Yasmine Dechraoui Bottein and Luisa Mangialajo, University of Côte d'Azur, France

Geographical scope: France, Spain, Italy, Monaco, Europe; Mediterranean and temperate Atlantic beaches

The marine microalga *Ostreopsis,* a toxic dinoflagellate living on the seabed (Accoroni and Totti, 2016), attaches to substrates such as macroalgae (Monserrat et al., 2024), creating a mucilaginous biofilm. The *Ostreopsis* genus, well known in tropical latitudes, has expanded rapidly in recent decades, now reaching temperate coastlines in Europe where recurrent summer blooms pose risks to human health and marine ecosystems (Tester et al., 2020). These recurrent blooms are associated with respiratory irritations and general malaise for beach users, decreased water bath quality and mass mortalities of seabed organisms (Berdalet et al., 2022).

In response, scientists from Monaco, France, Italy and Spain, coordinated under the RAMOGE Agreement[4], are working together to harmonize sampling and monitoring through a shared database and to contribute data to international networks[5]. This will provide improved knowledge about Ostreopsis blooms that is fundamental in preventing impacts on human health.

Following recent blooms on France's South Atlantic coasts in 2021, national French authorities

[4] See https://ramoge.org/en/ostreopsis-ovata-monitoring-programme/.
[5] Such as the ICES-IOC Working Group on Harmful Algal Blooms Dynamics.

requested a coordinated research and monitoring strategy (Lemée et al., 2023). As a result, information is being disseminated through outreach activities, as well as in coordination with water quality and public health agencies, city halls of affected beaches, lifeguards and various stakeholders.

Given the rapid growth of *Ostreopsis* blooms, and challenges for large-scale institutional monitoring, citizen science has emerged as a valuable means to identify at-risk sites. The blooms are easy to sample in shallow waters, and *Ostreopsis* cells are easily recognizable under a microscope. Simplified protocols using low-cost sampling tools, chip-portable microscopes and online platforms to upload data have therefore been developed for public use. Training sessions and field tests have shown that citizen involvement can speed up the detection and reporting of *Ostreopsis* blooms, with real-time information made available online to local stakeholders (Vila, et al., 2022; de Virgilio, 2021).

This case study showcases the importance of coordinated scientific research and citizen engagement in collating ocean observations for early-warning systems, targeted research and capacity building that respond to emerging threats to ocean health.

The co-produced, participatory approaches to science described have the power to foster mutual understanding, shared ownership of knowledge and international collaboration (Cooke et al., 2021; Djenontin and Meadow, 2018). By transcending sectoral and geopolitical barriers, they can lay the foundation for robust, long-term frameworks for shared global prosperity.

3. ADVANCING SCIENCE TO SAFEGUARD THE GLOBAL COMMONS AND STRENGTHEN GLOBAL COOPERATION

Strengthening cooperation through science and shared goals

The global ocean is interconnected, with processes in one region have far-reaching impacts beyond national boundaries. Yet, ocean sustainability is often challenged by the competing priorities and ambitions of neighbouring nations in transboundary contexts (Hildebrand and Alnor, 2024). In addition, the scale and intensity of ocean use have grown significantly in recent years, leading to heightened competition and an increased risk of conflicts driven by political, economic and social tensions (Blasiak et al., 2023). For instance, fisheries-related conflicts have been on the rise since 2000, driven not just by resource scarcity but also by territorial tensions and changing climate and fish distributions (Blasiak et al., 2023).

However, humankind's shared dependence on ocean health provides a strong foundation for fostering trust, collaboration and diplomacy among countries. Protecting the ocean is not only an ecological necessity, but also a strategic imperative for promoting global stability and cooperation. This reality underscores the urgent need for integrated and inclusive management, highlighting ocean health – and environmental health more broadly – as essential for preventing conflict and building peace.

Unfortunately, efforts towards shared ocean governance often overlook deep-seated asymmetries of power that marginalize people in the Global South. Despite being greatly affected by climate impacts and ocean degradation, many nations in the Global South are still underrepresented in relevant global decision-making platforms. Addressing these imbalances is critical to fostering genuinely cooperative and just ocean governance.

Amid escalating geopolitical tensions, scientific endeavours need to extend far beyond knowledge generation. Scientific collaboration can help reduce tensions, particularly in regions with shared marine resources or territorial disputes – by maintaining communication channels, reducing misunderstandings and building trust that contributes to regional or global stability. For instance, the North Pacific Marine Science Organization has facilitated collaboration amongst scientists from Canada, China, Japan, Korea, Russian Federation and the United States for more than 30 years, enabling continued data sharing, joint research and capacity building. Likewise, the Western Indian Ocean Marine Science Association has enhanced collaboration among coastal states including Somalia, Kenya, Tanzania, Mozambique, South Africa, Comoros and others (Blasiak et al., 2023).

Furthermore, by offering a shared, evidence-based foundation, science has the potential to depoliticize

contentious issues, support constructive negotiations and provide a roadmap for long-term, cooperative ocean governance (Blasiak et al., 2023). To facilitate these efforts, international governance must be anchored in inclusive science-policy processes that produce and integrate the best available science – alongside context-specific knowledge and practices to address systemic risks, and based on global priorities for sustainable management. Recent reform of global fisheries subsidies (Case Study 5) illustrates how such interdisciplinary, evidence-based inputs can inform policy negotiations leading to long-lasting, global impacts.

CASE STUDY 5

Supporting global cooperation through science – fisheries subsidy reform

Author: Rashid Sumaila, Institute for the Oceans and Fisheries and School of Public Policy and Global Affairs, University of British Colombia, Canada

Geographical scope: Global

Fisheries subsidies can be harmful to the ocean if they encourage overcapacity and overfishing. Each year, governments spend an estimated USD 35 billion on subsidies to the fishing sector; of this, USD 22 billion is spent on subsidies considered harmful (Sumaila et al., 2019). These subsidies serve as a major driver in the depletion of marine resources, distorting global markets, disproportionately benefiting large industrial fleets, and undermining the livelihoods of small-scale fishers, especially in low-income countries (Segerson et al., 2024).

Through interdisciplinary research, combined ecological and economic analyses have provided support for equity-based arguments to reform fisheries subsidies globally (Sumaila, 2024). This led to the development of the Global Fisheries Subsidies Database, which categorizes subsidies as beneficial, harmful or ambiguous, and simulates how they affect the health of fish stocks and global economic outcomes (Sumaila et al., 2010, 2019). As well as supporting policy analysis, the research also proposed equitable, sustainable and enforceable mechanisms for subsidy reform (Schuhbauer et al. 2020).

By collaborating with scientists, trade lawyers, diplomats, non-governmental organizations (e.g. Oceana and WWF), intergovernmental organizations (e.g. the Food and Agriculture Organization of the United Nations and the World Trade Organization), and policy-makers, the subsidies research team ensured that science informs critical policy negotiations. For instance, the work played a key role in the High Level Panel for a Sustainable Ocean Economy, and contributed evidence that led to the 2022 Agreement on Fisheries Subsidies, which bans certain forms of harmful subsidies.

This case study demonstrates the importance of interdisciplinary and policy-relevant science in addressing complex global subsidy systems and challenges. Moreover, it showcases how making data accessible can raise awareness among policy-makers and empower civil society, resulting in more equitable international rules. It also demonstrates the value of creating new synergies, or amplifying existing relationships and networks, to accelerate dialogue and action involving a broad range of marine stakeholders.

Science diplomacy and capacity building for equitable ocean decision-making

Science serves as 'a key vehicle for benefit-sharing' by enhancing scientific and technological capacity and supporting technology transfer, particularly in the Global South (Tessnow-von Wysocki and Vadrot, 2020). But limited access to marine technologies to observe, explore, monitor and sustainably manage resources leaves vast areas of the ocean unexplored, and constrains scientific discoveries and innovation. It also reduces the ability of countries in the Global South to contribute critical data and perspectives to international negotiations (Polejack and Coelho, 2021), reinforcing knowledge asymmetries, limiting the inclusiveness of global ocean governance, and ultimately leading to divergent positions that hinder progress towards a global consensus. In addition, when decisions rely on incomplete data that fail to capture the full diversity of marine ecosystems, regional challenges and locally grounded knowledge, they can lead to ineffective policies, oversights in environmental monitoring and missed opportunities for sustainable innovation.

Strengthening scientific and technological capacity is critical for global efforts to monitor and understand changes in the ocean, and to create long-term ocean resilience. At the same time, empowering all countries to engage in and apply scientific advances fosters inclusive international collaboration that goes beyond global management of the ocean. Realizing this potential requires equitable access to marine technologies, with science diplomacy playing a key role in facilitating access to data and fostering long-standing partnerships and collaboration among nations (Polejack and Coelho, 2021). The Marine and Coastal Area Management Project for North and West Africa (Case Study 6) exemplifies how this approach can work in practice. In particular, it demonstrates the impact of strengthening scientific capacity equitably, and equipping regional institutions with essential geospatial tools and training to enhance their ability to effectively manage coastal and marine resources.

CASE STUDY 6:
Enhancing fisheries management and maritime security with science and technology

Author: Kwame Adu Agyekum, Department of Marine and Fisheries Sciences, University of Ghana

Geographical scope: West and North Africa

Illegal, unreported, and unregulated fishing poses severe threats to marine ecosystems and economic stability across West and North Africa (Merem et al., 2019). The Marine and Coastal Areas Management in North and West Africa (MarCNoWA) project equips regional institutions with essential geospatial tools and training, empowering them to address these threats and effectively manage coastal and marine resources (University of Ghana, n.d.-a, n.d.-b).

Through partnerships with regional actors and with support from the African Union Commission and the European Union Commission, the MarCNoWA project provides essential services that guide fishers and fisheries managers to productive fishing areas. Utilizing satellite data and information gathered through the automatic identification system used by shipping, the service assesses various oceanic conditions and fishing behaviour. This enables the generation of predictive maps highlighting likely areas for fish aggregation, particularly for tuna species such as skipjack, yellowfin and bigeye (Agyekum et al., 2018).

Fisheries managers rely on these detailed maps to strategically plan patrol and surveillance activities, ensuring sustainable management

Photo: Canva

and conservation of fish stocks. In addition, the MarCNoWA project has developed advanced monitoring services to detect and respond swiftly to illegal fishing activities.

The MarCNoWA project works closely with government agencies, environmental groups, naval forces, and educational institutions across several African countries, including Gambia, Liberia, Sierra Leone, Ghana, Benin, Algeria, Tunisia and Nigeria. By encouraging the sharing of information and best practices, the project supports regional collaboration that not only enhances the management of fisheries but also fosters trust and shared responsibility for protecting marine resources (Ebel et al., 2018).

More equitable collaboration on identifying capacity gaps and targeting scientific investments requires accurate assessments of marine science and technology needs. Such assessments are best carried out by countries in the Global South with support from international organizations, scientific bodies and institutions, the private sector and national governments (Polejack and Coelho, 2021).

The Pacific Islands Ocean Acidification Centre (PIOAC) exemplifies how targeted partnerships can strengthen regional scientific capacity. Established in 2021 and led by the Secretariat of the Pacific Community, PIOAC provides training and technical assistance to address the impacts of ocean acidification across the Pacific Islands. Working in partnership with institutions such as the University of the South Pacific, the University of Otago and the National Institute of Water and Atmospheric Research, with funding and technical support from the Ocean Foundation and the United States National Oceanic and Atmospheric Administration, the Centre empowers local experts to monitor ocean acidification and apply data for climate adaptation and mitigation.

Addressing marine science and technology needs and existing asymmetries requires strategic investments in scientific infrastructure and knowledge sharing, particularly in a fragmented geopolitical context with leadership and funding vacuums. In this context, decentralized efforts by individual scientists and leadership from global science organizations are increasingly vital – to fill critical gaps, sustain momentum and uphold inclusive international collaboration as a cornerstone of resilient and just ocean governance.

4. POLICY RECOMMENDATIONS

- ***Invest in safeguarding ocean resilience and integrated science to secure co-benefits that strive to achieve global sustainability:*** Protecting ocean health is not just an environmental imperative but a strategic investment in global stability and human wellbeing. Governments should prioritize targeted investments in ocean resilience in order to generate or amplify synergies across policy domains.

- ***Advance inclusive, transparent and participatory governance of the ocean:*** Policy-makers should support mechanisms that ensure diverse perspectives, particularly those of Indigenous and local knowledge systems, are recognized and integrated into decision-making processes. Effective ocean governance must address power asymmetries and the persistent underrepresentation of the Global South in global platforms for ocean governance, crucial to ensuring equitable and effective international cooperation. Governance should build on integrated approaches and interdisciplinary collaborations that involve a wide range of stakeholders, including Indigenous communities, local actors and policy-makers. Empowering citizens, including youth, through public engagement and scientific literacy programmes can help counter disinformation, foster societal understanding of ocean challenges, and promote more participatory and accountable decision-making. Such inclusive approaches not only improve the legitimacy and effectiveness of governance efforts but also help ensure that the benefits of sustainable ocean management are equitably shared.

- ***Support interdisciplinary and transdisciplinary science and inclusive knowledge systems:*** Stakeholders across science and decision-making, including research institutions, policy-makers, community groups and civil society, must make science more accessible, socially embedded and directly relevant to decision-makers at all levels. Bridging the science, policy and society gap is a key prerequisite for effective ocean governance and innovation. Funding mechanisms and evaluation criteria should support interdisciplinary and policy-relevant, solutions-oriented research. They should also promote a shift towards transdisciplinary research, ensuring that marginalized voices are included in the research and decision-making processes. Additionally, investments should target fundamental scientific research as there are still areas where knowledge gaps persist.

- ***Leverage science cooperation as a diplomatic tool to build trust and manage shared resources:*** In a context of intensifying geopolitical tensions and competition for resources, ocean governance should leverage science as a vital tool for promoting peace and diplomacy. International efforts should focus on using collaborative ocean science to build mutual understanding, foster cross-border cooperation and address conflicts related to marine resources. This can also support peaceful resolution of resource competition in contested or transboundary marine areas, supporting stability and equitable participation in ocean governance.

- ***Prioritize long-term investments in ocean science and related infrastructure, capacity building and technology transfer:*** Governments and funding bodies must prioritize and increase long-term financial investments in ocean science, especially in regions facing high vulnerability and underinvestment. This includes support for capacity-building initiatives, enhanced data and knowledge-sharing systems, expanded observational infrastructure and equitable technology transfer. Strengthening scientific capacity worldwide is essential for informed decision-making, global consensus and coordinated action on shared sustainability challenges. In addition, assessing the financial inputs required for the conservation and sustainable use of ocean resources is critical for identifying funding gaps, mobilizing resources from diverse sources, and aligning financial flows with priorities outlined in the targets of Sustainable Development Goal 14.

- ***Harness UNOC-3 to strengthen science-based implementation, partnerships and accountability:*** UNOC-3 should serve as a key platform for inspiring collective action and international collaboration on ocean conservation, grounded in the latest scientific evidence. It should foster an enabling environment where countries can learn from one another's implementation experiences, mobilize science more effectively to inform decision-making, and catalyse multi-stakeholder partnerships that accelerate progress on ocean sustainability. To enhance the impact of voluntary commitments, UNOC-3 should also provide a mechanism for reviewing progress, sharing lessons learned, encouraging collaboration and promoting accountability, thereby strengthening transparency and trust in global ocean governance

5. CONCLUSION

Safeguarding our shared ocean is central to achieving human health and wellbeing, sustainable development and global stability. In a period of intersecting environmental, social, economic and geopolitical crises, integrated and cross-scale

Photo: Canva

approaches grounded in co-produced, participatory science can foster collaborative solutions and long-standing cooperation – capitalizing on momentum generated by the United Nations Decade of Ocean Science for Sustainable Development. Through leveraging such transformative solutions across a range of sustainability challenges, the international community has the power to ensure a collaborative, equitable and resilient future for our global ocean.

6. REFERENCES

Armstrong McKay, D. I., Staal, A., Abrams, J. F., Winkelmann, R., Sakschewski, B., Loriani, S., Fetzer, I., Cornell, S. E., Rockström, J., & Lenton, T. M. (2022). Exceeding 1.5°C global warming could trigger multiple climate tipping points. Science, 377(6611), eabn7950. https://doi.org/10.1126/science.abn7950

Bindoff, N. L., Cheung, W. W. L., Kairo, J. G., Arístegui, J., Guinder, V. A., Hallberg, R., Hilmi, N., Jiao, N., Karim, M. S., Levin, L., O'Donoghue, S., Purca Cuicapusa, S. R., Rinkevich, B., Suga, T., Tagliabue, A., & Williamson, P. (2019). Changing ocean, marine ecosystems, and dependent communities. In H.-O. Pörtner, D. C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, & N. M. Weyer (Eds.), *IPCC special report on the ocean and cryosphere in a changing climate* (in press). Intergovernmental Panel on Climate Change. https://www.ipcc.ch/site/assets/uploads/sites/3/2019/11/09_SROCC_Ch05_FINAL-1.pdf

Blasiak, R., Jouffray, J.-B., Norström, A., Queiroz, C., Wabnitz, C. C., & Österblom, H. (2023). The Ocean Decade as an instrument of peace. *Current Opinion in Environmental Sustainability, 64*, 1-7. https://doi.org/10.1016/j.cosust.2023.101319

Boers, N. (2021). Observation-based early-warning signals for a collapse of the Atlantic Meridional Overturning Circulation. *Nature Climate Change, 11*(8), 680-688. https://doi.org/10.1038/s41558-021-01097-4

Buonocore, E., Grande, U., Franzese, P. P., & Russo, G. F. (2021). Trends and evolution in the concept of marine ecosystem services: An overview. *Water, 13*(15), 1-14. https://doi.org/10.3390/w13152060

Caldeira, M., Sekinairai, A. T., & Vierros, M. (2025). Weaving science and traditional knowledge: Toward sustainable solutions for ocean management. *Marine Policy, 174*, 1-15. https://doi.org/10.1016/j.marpol.2025.106591

Cooke, S. J., Nguyen, V. M., Chapman, J. M., Reid, A. J., Landsman, S. J., Young, N., Hinch, S. G., Schott, S., Mandrak, N. E., & Semeniuk, C. A. (2021). Knowledge co-production: A pathway to effective fisheries management, conservation, and governance. *Fisheries, 46*(2), 89-97. https://doi.org/10.1002/fsh.10512

Djenontin, I. N. S., & Meadow, A. M. (2018). The art of co-production of knowledge in environmental sciences and management: Lessons from international practice. *Environmental Management, 61*(6), 885-903. https://doi.org/10.1007/s00267-018-1028-3

Gruber, N., Clement, D., Carter, B. R., Feely, R. A., Van Heuven, S., Hoppema, M., Ishii, M., Key, R. M., Kozyr, A., Lauvset, S. K., Monaco, C. L., Mathis, J. T., Murata, A., Olsen, A., Perez, F. F., Sabine, C. L., Tanhua, T. & Wanninkhof, R. (2019). The oceanic sink for anthropogenic CO2 from 1994 to 2007. *Science, 363*(6432), 1193-1199. https://doi.org/10.1126/science.aau5153

Hildebrand, L., & Alnor, P. (2024). *Policy brief: Addressing the fragmentation of ocean governance across borders.* eMSP NSBR Ocean Governance Learning Strand. https://www.emspproject.eu/wp-content/uploads/2024/01/Ocean-Governance-Policy-Brief-eMSP-NBSR-January-2024.pdf

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. (2019). *Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (Version 1)*. Zenodo. https://doi.org/10.5281/zenodo.6417333

International Science Council. (2023). *Policy brief: Creating a strong interface between science, policy and society to tackle global plastic pollution.* https://council.science/wp-content/uploads/2023/11/ISC_policy_brief_plastics_WEB.pdf

International Science Council. (2025). *Ocean at a tipping point: Science-based priorities for UNOC-3.* https://council.science/wp-content/uploads/2025/04/ISC_Science-based-priorities-for-UNOC3.pdf

Kaiser, M., & Gluckman, P. (2025). Are scientific assessments and academic culture impeding transformative science? *Sustainability Science, 20*(3), 1109-1116. https://doi.org/10.1007/s11625-025-01631-9

Kelly, R., Elsler, L. G., Polejack, A., van der Linden, S., Tönnesson, K., Schoedinger, S. E., Santoro, F., Pecl, G. T., Palmgren, M., Mariani, P., Glithero, D., Evans, K., Cvitanovic, C., Cook, J., Bartram, J., & Wisz, M. S. (2022b) Empowering young people with climate and

ocean science: Five strategies for adults to consider. *One Earth, 5*(8), 861-874. https://doi.org/10.1016/j.oneear.2022.07.007

Kelly, R., Evans, K., Alexander, K., Bettiol, S., Corney, S., Cullen-Knox, C., Cvitanovic, C., de Salas, K., Emad, G. R., Fullbrook, L., Garcia, C., Ison, S., Ling, S., Macleod, C., Meyer, A., Murray, L., Murunga, M., Nash, K. L., Norris, K., ... Pecl, G. T. (2022a). Connecting to the oceans: supporting ocean literacy and public engagement. *Reviews in Fish Biology and Fisheries, 32*, 123-143. https://doi.org/10.1007/s11160-020-09625-9

Lah, O. (2025). Breaking the silos: Integrated approaches to foster sustainable development and climate action. *Sustainable Earth Reviews, 8*(1), 1-15. https://doi.org/10.1186/s42055-024-00102-w

Lund, K., Dinse, K., Callewaert, J., & Scavia, D. (2011). Benefits of using integrated assessment to address sustainability challenges. *Journal of Environmental Studies and Sciences, 1*, 289-295. https://doi.org/10.1007/s13412-011-0047-7

Österblom, H., Wabnitz, C. C. C., & Tladi, D. (2020). *Towards ocean equity.* High Level Panel for a Sustainable Ocean Economy. https://oceanpanel.org/publication/towards-ocean-equity/

Pelc, R., & Fujita, R. M. (2002). Renewable energy from the ocean. *Marine Policy, 26*(6), 471-479. https://doi.org/10.1016/S0308-597X(02)00045-3

Pendleton, L. H., Alexandroff, S. J., Clausen, A., Schmidt, J. O., & Browman, H. I. (2023). Co-designing marine science for the ocean we want. *ICES Journal of Marine Science, 80*(2), 342-346. https://doi.org/10.1093/icesjms/fsad018

Polejack, A., & Coelho, L. F. (2021). Ocean science diplomacy can be a game changer to promote the access to marine technology in Latin America and the Caribbean. *Frontiers in Research Metrics and Analytics, 6*, 1-11. https://doi.org/10.3389/frma.2021.637127

van Noort, C. (2025). A model for co-designing and co-delivering ocean science knowledge and solutions. In *International collaboration in ocean science and governance* (pp. 39–66). Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-031-85378-4_2

Worm, B., Elliff, C., Fonseca, J. G., Gell, F. R., Serra-Gonçalves, C., Helder, N. K., Murray, K., Peckham, H., Prelovec, L., & Sink, K. (2021). Making ocean literacy inclusive and accessible. *Ethics in Science and Environmental Politics, 21*, 1-9. https://doi.org/10.3354/esep00196

Tessnow-von Wysocki, I., & Vadrot, A. B. M. (2020). The voice of science on marine biodiversity negotiations: A systematic literature review. *Frontiers in Marine Science, 7*, 1-26. https://doi.org/10.3389/fmars.2020.614282

U.S. Environmental Protection Agency. (n.d.). *Climate change impacts on coasts*. https://www.epa.gov/climateimpacts/climate-change-impacts-coasts

Case study 1

Bailey, M., Favaro, B., Otto, S. P., Charles, A., Devillers, R., Metaxas, A., Tyedmers, P., Ban, N. C., Mason, T., Hoover, C., Duck, T. J., Fanning, L., Milley, C., Cisneros-Montemayor, A. M., Pauly, D., Cheung, W. W. L., Cullis-Suzuki, S., Teh., L., & Sumaila, U. R. (2016). Canada at a crossroad: The imperative for realigning ocean policy with ocean science. *Marine Policy, 63*, 53-60. https://doi.org/10.1016/j.marpol.2015.10.002

Bennett, N. J., Di Franco, A., Calò, A., Nethery, E., Niccolini, F., Milazzo, M., & Guidetti, P. (2019). Local support for conservation is associated with perceptions of good governance, social impacts, and ecological effectiveness. *Conservation letters, 12*(4), 1-10. https://doi.org/10.1111/conl.12640

Harper, S., Salomon, A. K., Newell, D., Waterfall, P. H., Brown, K., Harris, L. M., & Sumaila, U. R. (2018). Indigenous women respond to fisheries conflict and catalyze change in governance on Canada's Pacific Coast. *Maritime Studies, 17*, 189-198. https://doi.org/10.1007/s40152-018-0101-0

Lam, V. W., Allison, E. H., Bell, J. D., Blythe, J., Cheung, W. W., Frölicher, T. L., Gasalla, M. A., & Sumaila, U. R. (2020). Climate change, tropical fisheries and prospects for sustainable development. *Nature Reviews Earth & Environment, 1*(9), 440-454. https://doi.org/10.1038/s43017-020-0071-9

Sumaila, U. R., Armitage, D., Bailey, M., & Cheung, W. (Eds.). (2024). *Sea change: charting a sustainable future for oceans in Canada.* University of British Columbia Press.

Case study 2

Nawaz, S., Bood, N., & Shal, V. (2017). *Natural heritage, natural wealth: Highlighting the economic benefits of the Belize Barrier Reef Reserve System World Heritage Site* (World Wildlife Fund Technical Report). http://fragmentsofhope.org/

Case study 3

https://www.usp.ac.fj/pace-sd/projects/protectpacific/output-1/volume-1/

Case study 4

Accoroni, S., & Totti, C. (2016). The toxic benthic dinoflagellates of the genus Ostreopsis in temperate

areas: a review. *Advances in Oceanography and Limnology, 7*(1), 1-15. https://doi.org/10.4081/aiol.2016.5591

Berdalet, E., Pavaux, A. S., Abós-Herràndiz, R., Travers, M., Appéré, G., Vila, M., Thomas, J., de Haro, L., Estrada, M., Medina-Pérez, N. I., Viure, L., Karlson, B., & Lemée, R. (2022). Environmental, human health and socioeconomic impacts of Ostreopsis spp. Blooms in the NW Mediterranean. *Harmful Algae, 119*, 1-16. https://doi.org/10.1016/j.hal.2022.102320

Lemée, R., Humbert, J.-F., Abadie, E., Amzil, Z., Berdalet, E., Biré, R., Dechraoui Bottein, M.-Y., de Haro, L., Delcourt, N., Fessard, V. H., Jaeg, J.-P., Mattei, C., Oppliger, A., Pavaux, A.-S., Ternon, E., Bornert, G., Humbert, J.-F., Togola, A., Baron, J., ... Ney, E. (2023). *Avis de l'Anses relatif aux risques pour la santé humaine liés aux proliférations d'Ostreopsis spp. sur le littoral basque*. Anses. https://anses.hal.science/anses-04169914/

Monserrat, M., Asnaghi, V., Verdura, J., Meroni, L., Lemée, R., Rossi, A. M., Romero, G., Priouzeau, F., Chiantore, M., & Mangialajo, L. (2024). From micro to mesoscale: Understanding the influence of macroalgal communities on Ostreopsis Schmidt blooms. *Harmful Algae, 136*, 1-12. https://doi.org/10.1016/j.hal.2024.102650

Tester, P. A., Litaker, R. W., & Berdalet, E. (2020). Climate change and harmful benthic microalgae. Harmful Algae, 91, 1-27. https://doi.org/10.1016/j.hal.2019.101655

Vila, M., Viure, L., Lemée, R., Berdalet, E. (2022). Developing an Ostreopsis early warning system: The joint engagement of scientists, environmental agencies, and community science. In: Band-Schmidt, C.J. and Rodríguez-Gómez, C.F. (Eds.). Proceedings of the 19th International Conference on Harmful Algae, La Paz, B.C.S., Mexico. *International Society for the Study of Harmful Algal Blooms,* 310-315. https://doi.org/10.5281/zenodo.7033157

de Virgilio, M., Cifarelli, S., Garofoli, G., Lamberti, G., Massari, V., & Degryse, B. (2021). Citizen science in the monitoring of Ostreopsis ovata blooms in southern Italy: A five-year study. *Marine Pollution Bulletin, 173*, 1-12. https://doi.org/10.1016/j.marpolbul.2021.112981

Case study 5

Schuhbauer, A., Skerritt, D. J., Ebrahim, N., Le Manach, F., & Sumaila, U. R. (2020). The global fisheries subsidies divide between small-and large-scale fisheries. *Frontiers in Marine Science, 7*, 1-9. https://doi.org/10.3389/fmars.2020.539214

Segerson, K., Polasky, S., Scheffer, M., Sumaila, U. R., Cárdenas, J. C., Nyborg, K., Fenichel, E. P., Anderies, J. M., Barrett, S., Bennett, E. M., Carpenter, S. R., Crona, B., Daily, G., de Zeeuw, A., Fischer, J., Folke, C., Kautsky, N., Kremen, C., Levin, S. A., ... & Weber, E. U. (2024). A cautious approach to subsidies for environmental sustainability. *Science, 386*(6717), 28-30. https://doi.org/10.1126/science.ado2615

Sumaila, U. R. (2024). Reflections on breaking down silos in fisheries science. *Fisheries, 49*(5), 207-210. https://doi.org/10.1002/fsh.11076

Sumaila, U. R., Ebrahim, N., Schuhbauer, A., Skerritt, D., Li, Y., Kim, H. S., Mallory, T. G., Lam, V. W. L., & Pauly, D. (2019). Updated estimates and analysis of global fisheries subsidies. *Marine Policy, 109*, 1-11. https://doi.org/10.1016/j.marpol.2019.103695

Sumaila, U. R., Khan, A. S., Dyck, A. J., Watson, R., Munro, G., Tydemers, P., & Pauly, D. (2010). A bottom-up re-estimation of global fisheries subsidies. *Journal of Bioeconomics, 12,* 201-225. https://doi.org/10.1007/s10818-010-9091-8

Case study 6

Agyekum, K. A., Wiafeg, G., & Nunoo, F. K. E. (2018). Mapping of potential fishing zone in support of fisheries management in West Africa. *Science and Development, 2*(1), 2-11.

Ebel, S. A., Beitl, C. M., Runnebaum, J., Alden, R., & Johnson, T. R. (2018). The power of participation: Challenges and opportunities for facilitating trust in cooperative fisheries research in the Maine lobster fishery. *Marine Policy, 90*, 47-54. https://doi.org/10.1016/j.marpol.2018.01.007

Merem, E. C., Twumasi, Y., Wesley, J., Alsarari, M., Fageir, S., Crisler, M., Romorno, C., Olagbegi, D., Hines, A., Ochai, G. S., Nwagboso, E., Legget, S., Foster, D., Purry, V., & Washington, J. (2019). Analyzing the tragedy of illegal fishing on the West African coastal region. I*nternational Journal of Food Science and Nutrition Engineering, 9*(1), 1-15. https://www.doi.org/10.5923/j.food.20190901.01

University of Ghana. (n.d.-a). *Marine and coastal areas management in North and West Africa* (MarCNoWA). Regional Marine Centre. https://geoportal.gmes.ug.edu.gh/#/

University of Ghana. (n.d.-b). *Welcome to the MarCNoWA web service portal.* Regional Marine Centre. https://oil-vessel-detection.vercel.app/

Connect with us at:

council.science

secretariat@council.science

International Science Council
5 rue Auguste Vacquerie
75116 Paris, France

linkedin.com/company/international-science-council/
facebook.com/InternationalScience
threads.net@council.science
bsky.app/profile/council.science
instagram.com/council.science
youtube.com/c/InternationalScienceCouncil
council.science/podcast/

***Acknowledgements**: This material is based upon work supported by the National Science Foundation under Award No. 2001326. Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.*