Ocean at a tipping point:

Science-based priorities for UNOC-3

International Science Council

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This report is published by the International Science Council,
5 rue Auguste Vacquerie, 75116 Paris, France.

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Cover photograph: Image by Wirestock on Freepik
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High-level scientific insights for the Nice Ocean Declaration

Overall, the 2025 UN Ocean Conference (UNOC) should focus on key developments and progress since the last Ocean Conference, while also providing leadership in integrating global agendas with ocean-relevant priorities to inspire comprehensive, action-oriented commitments that support just, resilient, and sustainable development. Urgent action to better support a healthier, well-functioning ocean is critical not only for achieving the Agenda 2030 as a whole, but also for preventing further environmental degradation and the escalation of irreversible impacts of climate change as well as non-climatic stressors. Beyond providing critical services such as ship transport, renewable energy, and nutrition for a growing global population, the ocean makes fundamental contributions to human health and well-being (Fleming et al., 2024). UNOC-3 should emphasize that investing in integrated, ecosystem-based ocean governance benefits both humanity and marine ecosystems as an interconnected system.

Key overarching science-based actions:

1. Address ocean system disruption and escalating environmental impacts: Prioritize urgent, science-based action to limit the risks and impacts of climate change and other non-climatic stressors on ocean health. Focus on preventing irreversible shifts in ocean circulation and ecosystem degradation by tackling root causes such as greenhouse gas emissions (GHG) and multiple local pressures, while implementing adaptation strategies to safeguard ocean health and human well-being.

2. Implement integrated, ecosystem-based ocean governance: Promote a science-based, integrated governance approach that emphasizes ecosystem-based management to enhance the resilience of marine ecosystems to warming, ocean acidification, deoxygenation, pollution, and overfishing. This approach must account for the dynamic and shifting nature of marine ecosystems in a warming ocean, incorporating ecosystem-based adaptation as a key strategy. It should also be guided by the latest scientific understanding of cumulative effects of multiple stressors and prioritize multi-sectoral, coordinated policies that advance both planetary health and sustainable development.

3. Strengthen science and technology for ocean monitoring and evidence-based decision-making: Scale up investments in ocean science and technology, particularly in the Global South, with enhanced cooperation to strengthen long-term ocean observation systems, climate services, biodiversity monitoring, and early warning systems. Focus should be on the deployment of a simple, fit-for-purpose, and cost-effective global ocean observing system, expanding observational capacities, addressing deep-ocean data gaps, and improving early warning systems – whilst centring equitable governance to guide this observation (Ota et al., 2024). These efforts will provide critical tools to establish data governance tools that can respond to priorities of coastal communities, assess tipping points in ocean health and functioning, thereby supporting the relevance of ocean science for evidence-based decision-making for global sustainability.

CURRENT TRENDS AND STATE OF THE OCEAN

1. The 2025 UNOC needs to address more centrally the new reality of a disrupted Earth system with accelerating climate change and environmental stressors, resulting in major changes in ocean functioning and health, with significant impacts on people and ecosystems.

- We are faced with several irreversible changes, partly related to the ocean's diminishing efficacy to absorb carbon dioxide emissions and excess heat from human activities, ocean acidification and deoxygenation, sea level rise and increasing risks of abrupt changes at an unprecedented rate (Bates and Johnson, 2020). These include disruptions to ocean currents and the melting of Arctic sea ice and polar continental ice sheets, which have significant implications on ocean circulation patterns.

- The ocean's capacity to act as a carbon sink is weakening due to decreased ocean buffer capacity and altered global ocean circulation (Müller et al., 2023), exacerbating climate change in ways that are increasingly difficult to project and increasing the risk of abrupt, irreversible shifts.

- We are seeing a decline in natural systems, as reflected in biodiversity loss and ecosystem shifts. Intensifying human pressures are driving a loss of marine ecosystem health and interconnected human health, with degraded habitats and declining biodiversity undermining the ocean's capacity to support livelihoods and wellbeing, provide coastal protection, and strengthen climate resilience.

- This disrupted Earth system demands that the UNOC recognizes the intrinsic and relational values of marine ecosystems, shifting from a solely human-centric perspective to one that includes the concepts of "Earth heritage" and social-ecological systems, and recognizes the plural values of nature and nature's contributions to people (Lundquist et al., 2023).

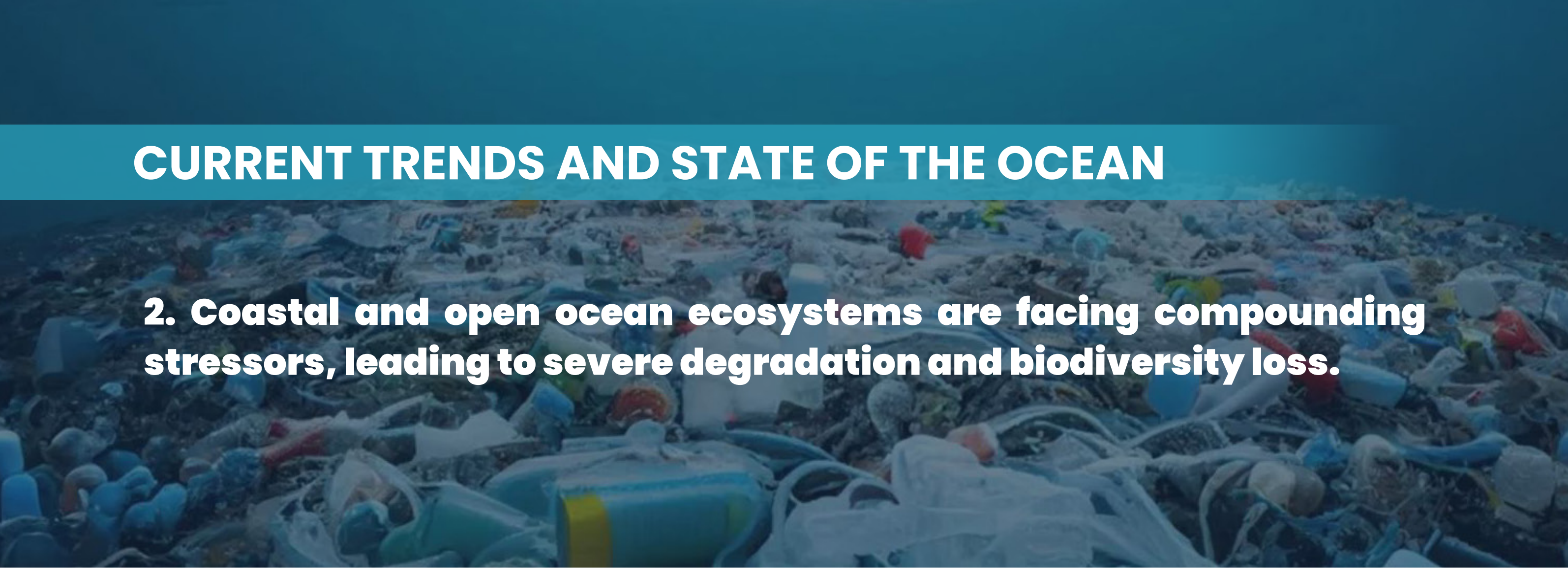
Recommended action areas for UNOC and its outcome document:

- Recognize explicitly the rapid and extensive changes to the ocean that are taking place and affecting critical ecosystem functioning, including the long-term sustainability of ocean and fishery resources (Sumaila, 2021). This requires recognizing the explicit role of science in projecting future change, better understanding human interdependence on marine ecosystems and the need for further investments in ongoing and future research.

- Better recognize the irreversibility of changes already underway in ocean systems, as well as future changes resulting from GHG and other human induced environmental factors, which will continue to affect ocean systems and their functioning.

- Emphasize the need for an integrated approach to ocean governance that values marine biodiversity to support policies that prioritize planetary health alongside human wellbeing and needs.

CURRENT TRENDS AND STATE OF THE OCEAN



2. Coastal and open ocean ecosystems are facing compounding stressors, leading to severe degradation and biodiversity loss.

- Marine ecosystems are facing intense and growing pressure from multiple, interacting stressors such as ocean acidification, ocean warming, marine heatwaves, pollution, overexploitation, and overfishing. The combined effects of these stressors can be unpredictable and may result in outcomes that are more severe, or entirely different from the effects of each stressor in isolation (Laffoley and Baxter, 2019).

- Climate change is altering the biogeochemical conditions of the ocean, leading to the emergence of novel environmental conditions and ecosystems. These changes may result in the migration or extinction of culturally and economically important species. Emerging scientific evidence indicates that by 2100, 60%–87% of the ocean is expected to experience novel conditions across multiple biogeochemical variables. These changes could be significant enough to undermine much of the progress made in ocean protection (Johnson and Watson, 2021).

- Rapidly altering ocean oxygen and carbon concentrations due to climate change is equally threatening deep-sea ecosystems, where conditions are usually stable, and species are adapted to long-term constancy. While some species may relocate, many long-lived, habitat-forming species that thrive in these stable, biodiverse environments may struggle to keep pace with these rapid changes, potentially leading to irreversible impacts on deep-sea ecosystems (Ross et al., 2020), of which we have limited understanding to date.

- The bioaccumulation and biomagnification of pollutants pose escalating threats to marine life and human health. Every year up to 400 million tonnes of pollutants, including thousands of chemicals, nutrients, plastics, toxic heavy metals, pharmaceutical substances, cosmetic products, and pathogens, are still being discharged into lakes, rivers and seas (World Ocean Review, 2021). The cumulative effects of these pollutants and mechanisms of biomagnification and bioaccumulation are poorly understood.

- Microplastics and nanoplastics, in particular, are now found in the deepest parts of the ocean in deep sea sediments (Barrett et al., 2020) and in marine organisms at every trophic level (Wright, 2013). It is estimated that between 0.8 and three million tonnes of microplastics enter Earth's oceans in a year (Boucher and Friot, 2017). These particles, which can absorb and accumulate pollutants, can cross biological barriers, posing unknown risks to oceanic food webs and human health. Additionally, plastic production presently accounts for 4.5% of global GHG emissions (Stegmann et al., 2022), with projections indicating a 60% increase in 2040 compared to 2020 levels (OECD, 2024), potentially further exacerbating impacts on the ocean.

- About 60% of global marine ecosystems have already been degraded or unsustainably used (Buonocore et al., 2021), further eroding their ability to support livelihoods, protect coasts, and provide climate resilience.

Recommended action areas for UNOC and its outcome document:

- Commit to addressing compounding stressors on marine ecosystems through coordinated, science-informed action plans that integrate climate adaptation, pollution control, biodiversity conservation, and the reduction of GHG emissions, while ensuring effective financing, monitoring, control and evaluation.

- Support research on the interactions among the multiple ocean stressors to inform effective strategies to address deoxygenation, protect vulnerable species, and enhance ecosystem resilience in the face of ongoing environmental change.

- Support research to better understand ocean changes due to the emergence of new marine environmental conditions and integrate that information into current and future management and adaptation efforts to safeguard socio-environmental resilience.

- Support comprehensive monitoring systems, robust environmental regulations, and decisive coordinated action to prevent further damage, mitigate marine pollution and safeguard ecosystems and human well-being.

- Support the design, management and development of indicators to evaluate the effectiveness of Marine Protected Areas (MPAs) in addressing cumulative stressors and adapting to shifting ecological conditions driven by environmental change.

- Support and adopt ambitious, binding commitments to reduce marine pollution (such as the current negotiations on an international legally binding treaty to end plastic pollution), heavy metals, and other hazardous materials, as well as nutrient pollution, which are specifically included in Target 14.1.

- Promote global and regional frameworks to monitor, regulate, and phase out harmful substances, while redirecting harmful subsidies toward investment in green jobs and research to better understand their ecological and health impacts and to develop sustainable alternatives.

- Adopt transformative, ecosystem-based management (EBM) to restore ocean ecosystems and address anthropogenic impacts and root causes of ocean degradation. This approach aims to integrate sustainable practices, reduce pollution, restore habitats, and enhance biodiversity, balancing human activities with ecosystem resilience to address present and future challenges.

- Promote strengthened international cooperation to protect vulnerable ecosystems, including deep-sea environments, with a focus on developing sustainable practices and restoring degraded habitats.

CURRENT TRENDS AND STATE OF THE OCEAN

3. Intensifying ocean-related extremes are driving escalating socio-economic and environmental costs, especially for vulnerable coastal communities.

- Marine heatwaves are becoming more frequent and severe, with record temperatures in 2023 and 2024 (Huang et al., 2024) – such 'super-marine heatwaves' cause mass coral bleaching and disrupt fisheries (Cheung et al., 2021), altering nutrient cycles. For instance, the 2024 event marks the fourth global coral bleaching event since 1998 (NOAA, 2024). These warming oceans also fuel extreme weather events like hurricanes and extreme rainfall by increasing evaporation and atmospheric moisture, amplifying their intensity and socio-economic losses and damages.

- Intensifying ocean-related disasters are driving up socio-economic costs, posing a growing threat to sustainable development. For example, El Niño/La Niña events occurring in the Pacific caused worldwide economic impacts far exceeding earlier estimates, exposing the vulnerability of our interconnected economic and social systems to ocean-driven changes (Future Earth et al., 2024).

- It is estimated that 680 million people currently live in the low-lying coastal zone, with projections indicating this number could exceed one billion by 2050 (IPCC, 2019). These areas are increasingly vulnerable to flooding, storms and tsunamis, further escalating exposure and risks to lives, infrastructure, and economies, particularly in vulnerable contexts such as Small Island Developing States (SIDS) and Large Ocean States (LOS).

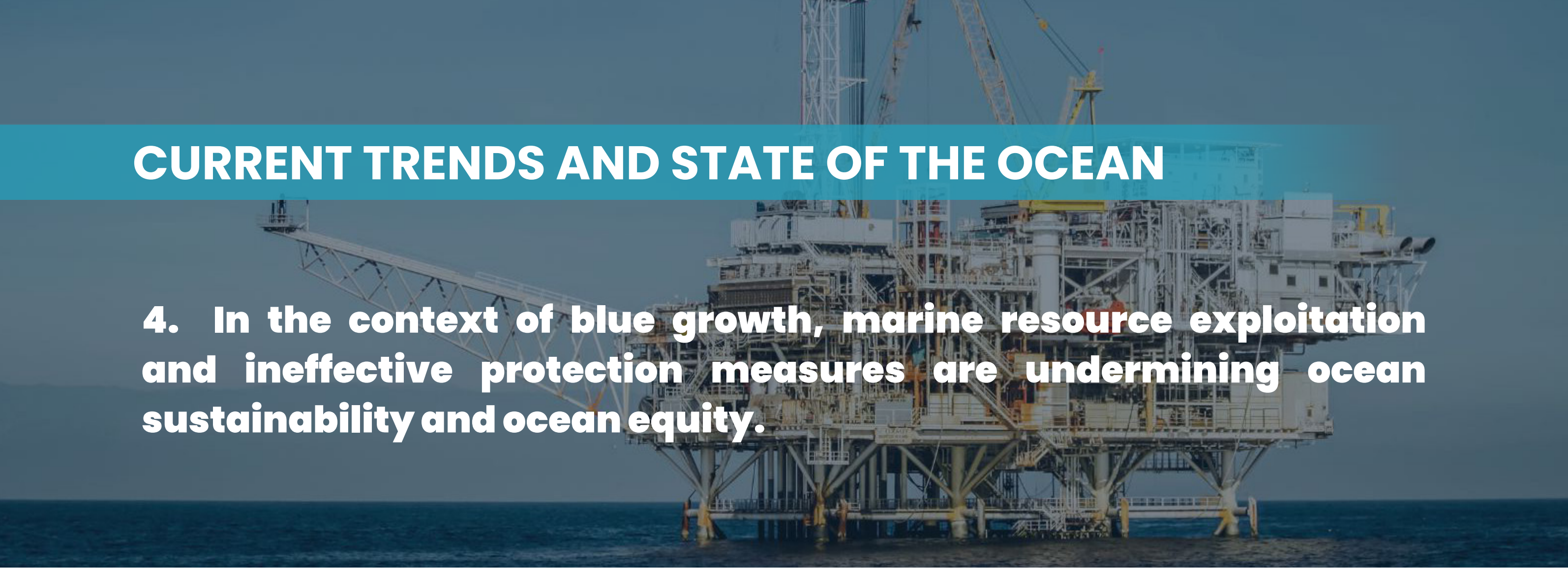
Recommended action areas for UNOC and its outcome document:

- Prioritize support for vulnerable coastal communities, including SIDS, by committing to enhanced early-warning systems, resilient infrastructure, and inclusive adaptation financing (building on the outcomes of the SIDS4 conference).

- Emphasize the need to address the root causes of escalating ocean extremes and the increasing frequency of ocean-atmosphere events and their cascading effects on global economies and societies.

- Promote the development of advanced early-warning systems and response mechanisms to minimize socio-economic costs from ocean-related extremes and improve resilience.

- Strengthen capacities and tools for monitoring tipping points, like potential changes in ocean currents, as these abrupt changes can dramatically affect marine ecosystems.



CURRENT TRENDS AND STATE OF THE OCEAN

4. In the context of blue growth, marine resource exploitation and ineffective protection measures are undermining ocean sustainability and ocean equity.

- Resource extraction in the ocean, including extraction of non-renewable resources such as fossil fuels, destructive fishing practices, and deep-sea mining, reflects significant trade-offs between the ocean economy and environmental sustainability.
- Deep-sea mining, often portrayed as essential for the green transition or as a solution to reducing child labour in terrestrial mines, also poses significant threats to unique biodiversity (Sumaila et al., 2023), including potential genetic resources. Emerging research indicates that deep-sea mining could cause irreversible damages to unique ecosystems and ecological functions of the ocean floor, releasing stored carbon and disrupting global biogeochemical cycles (Amon et al., 2022).
- Significant knowledge gaps persist regarding deep-sea ecosystems, their resilience and species interactions, hindering accurate assessment of seabed mining impacts and marine protection (European Academies Science Advisory Council, 2023).
- Over the past two decades, global MPA coverage has expanded rapidly. However, increasing evidence suggests there is substantial overestimation of both the extent and effectiveness of this protection as many MPAs lack robust management and regulations (Pike et al., 2024), are developed and implemented without proper engagement with local coastal communities and Indigenous Peoples (Ban and Frid, 2018; Strand et al., 2024), and are ineffective in addressing climate-driven ecological shifts or pollution impacts, including alterations in ecosystem composition, structure, and function, which are already evident and projected to intensify (Hoppit et al., 2022). Research also suggests that MPA designation alone cannot mitigate pollution-related impacts as many MPAs are located near pollution sources (Ghaemi et al., 2024).

Recommended action areas for UNOC and its outcome document:

- Adopt a precautionary approach to deep-sea mining until comprehensive scientific assessments of its impacts are completed, and sustainable alternatives are identified.
- Building a shared knowledge base through international collaboration to effectively address gaps and enable informed decision-making to safeguard deep-sea ecosystems, including assessments of equitable benefit sharing.
- Strengthen commitments to ensure MPAs are co-designed, co-developed and co-governed with coastal communities and Indigenous Peoples, and to effective MPAs that are scientifically designed, equity-centered, climate-adaptive, well-managed, and adequately funded, with a focus on climate-driven shifts and pollution impacts.
- Ensure strict enforcement of international agreements on sustainable marine resource use, human rights and the rights of Indigenous Peoples, small-scale fishers and coastal communities (Strand et al., 2024).

SCIENCE, KNOWLEDGE AND TECHNOLOGY-RELATED CROSS-CUTTING AREAS FOR COLLECTIVE ACTION

1. Strengthen international cooperation for science and technology (S&T) capacities and financing to support sustainable ocean management and SDG 14 implementation.

- Commit to strengthened international cooperation with a focus on deeper engagement with and leadership by the Global South, ensuring that countries in the Global North increase their support and investments in capacity-building, including for early-career researchers, technicians, and engineers. This effort should also focus on enhancing access to higher education and research programs, while promoting the sharing of scientific and technical expertise and supporting the development of regional initiatives led by the Global South.

- Enhance regional data-sharing frameworks and strengthen S&T capacities, particularly in the Global South, to support effective governance and improve the collaborative management of marine resources.

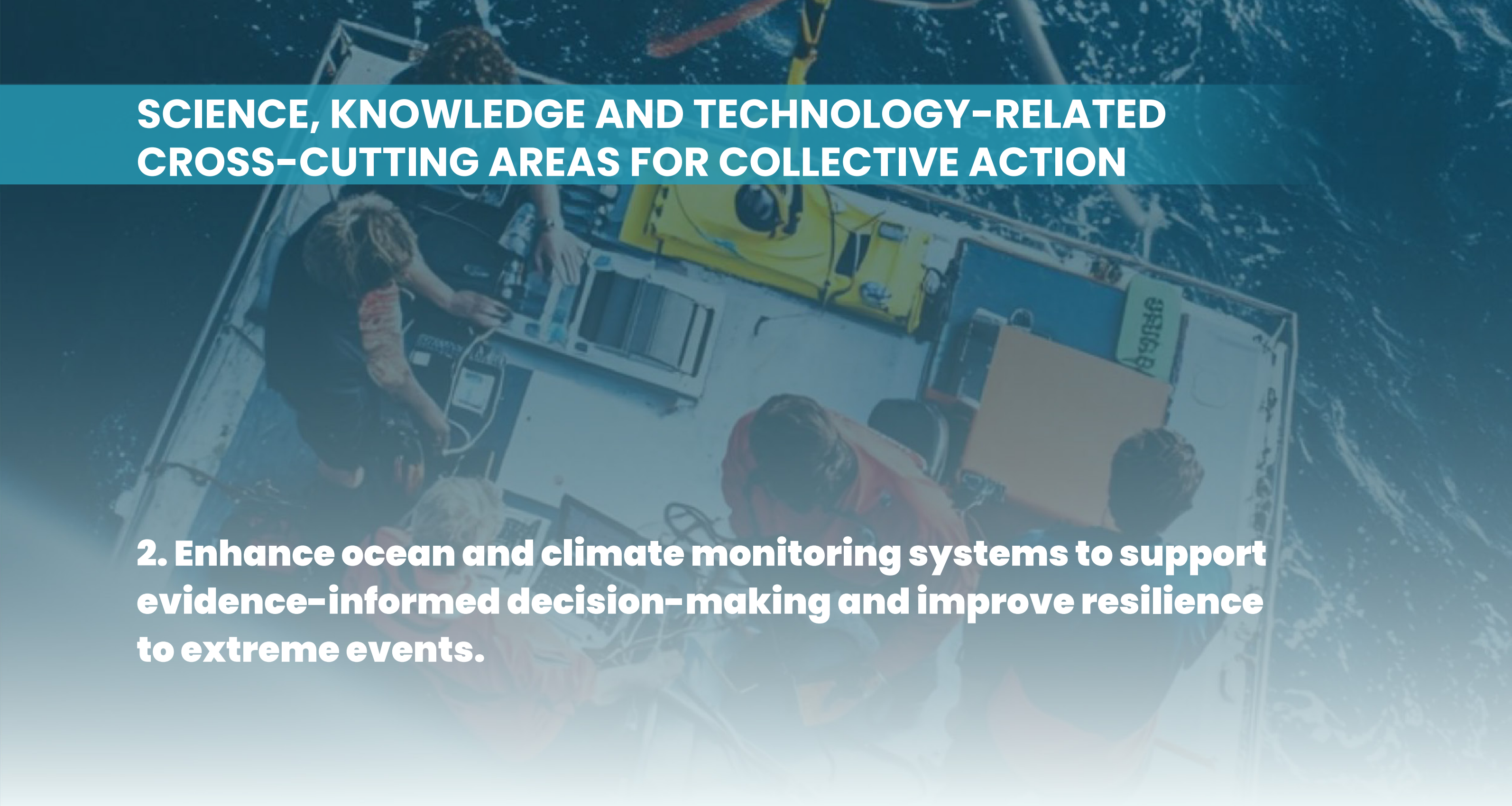
- Assess the financial needs required for ocean conservation and sustainable use to identify funding gaps, mobilize resources from diverse sources, and align financial flows with the priorities outlined in the SDG 14 targets. A comprehensive assessment can inform adequate financial support for key areas such as equitable marine protection, sustainable fisheries, and inclusive ocean-based economies, facilitating long-term ocean sustainability.

- Promote knowledge co-production and co-design processes, as well as transdisciplinary approaches, to underpin best available scientific evidence by supporting partnerships with Indigenous Peoples, local and traditional communities as genuine collaborators ensuring fully inclusive ocean sustainability strategies.

- Commit to supporting the co-production of sustainable ocean plans with Indigenous and traditional knowledge holders, ensuring that Indigenous Peoples are actively participating in self-governing, co-managing, and stewarding ocean areas. Acknowledge knowledge plurality, recognizing that multiple understandings of the ocean, some of which may currently be excluded, are essential for shaping equitable ocean science narratives.

- Empower local communities, enhance ecosystem restoration, promote climate adaptation, and reduce disaster risks to support sustainable livelihoods, strengthen resilience and contribute to address challenges towards advancing multiple SDGs.

- Leverage existing frameworks such as the UN Decade of Ocean Science for Sustainable Development to improve and contextualize ocean literacies (Strand et al., 2023), foster interdisciplinary collaboration, and inform knowledge- and evidence-based policy-making.



SCIENCE, KNOWLEDGE AND TECHNOLOGY-RELATED CROSS-CUTTING AREAS FOR COLLECTIVE ACTION

2. Enhance ocean and climate monitoring systems to support evidence-informed decision-making and improve resilience to extreme events.

- Support the development of a sustainable, fit-for-purpose and cost-effective ocean observing system critical for accurate forecasting of weather and ocean-related hazards, monitoring ongoing changes, assessing impacts and enhancing preparedness to deal with hazards with multifaceted impacts. The development of governance systems designed around equity (Ota et al., 2024), and the employment of frugal and low-cost equipment is crucial for enabling monitoring by, in and for low-income countries and facilitating public participation in citizen science initiatives.

- Strengthen ocean monitoring systems by addressing their fragility, reliance on short-term research funding, and lack of operational support for long-term data collection. Combining satellite and in-situ observations is essential to monitor deep-sea and remote areas and address data gaps.

- Enhance international funding and collaboration to ensure stable observational capacity providing robust information to improve adaptation and resilience to multiple stressors. This should leverage initiatives like the Global Ocean Observing System, Global Climate Observing System, and World Climate Research Programme.

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