Vision 2030
White Paper

Challenge 1
Understand and beat marine pollution

Zero Draft - January 2024
The Decade Coordination Unit of IOC/UNESCO extends its sincere appreciation to the co-chairs and members of the Working Group for their leadership and commitment in the process of drafting and authoring the draft White Paper. The draft White Paper is a foundation for diverse stakeholders to provide comments and suggestions, and its contents will be refined and complemented following the public review process. A revised version of the White Paper will be presented and discussed at the 2024 Ocean Decade Conference in Barcelona, before being finalized and published as part of UNESCO's Ocean Decade Series of publications.
VISION 2030 WHITE PAPER

ZERO DRAFT – JANUARY 2024

CHALLENGE 1: UNDERSTAND AND BEAT MARINE POLLUTION

Understand and map land- and sea-based sources of pollutants and contaminants and their potential impacts on human health and ocean ecosystems, and develop solutions to remove or mitigate them.
# Table of Contents

Acknowledgements ........................................................................................................ i

Acronyms ........................................................................................................................ 2

1. Executive summary .................................................................................................. 3
   1.1. Overview of the Ocean Decade Challenge .................................................. 3
   1.2. Key findings and recommendations ............................................................. 3

2. Introduction ............................................................................................................... 4
   2.1. Background and context of the Challenge ................................................... 4
   2.2. Overview of current work in the Ocean Decade .......................................... 6
   2.3. Importance and relevance of the Challenge for sustainable development .. 7
   2.4. Methodology for strategic ambition setting ................................................ 7

3. Strategic ambition setting ....................................................................................... 7
   3.1. Analysis of user needs and priorities ........................................................... 7
   3.2. Definition of the strategic ambition for the Challenge ................................. 8
      3.2.1. Priority datasets .................................................................................... 9
      3.2.2. Knowledge generation and sharing ..................................................... 10
      3.2.3. Infrastructure requirements ................................................................. 11
      3.2.4. Partnerships and resources ................................................................. 12
      3.2.5. Capacity development and exchange needs ........................................ 13
      3.2.6. Technology and innovation solutions .................................................. 14
   3.3. Integration, synergies and interdependencies with other Challenges ...... 15

4. Milestones and indicators ....................................................................................... 15
   4.1. Key milestones to measure progress and success ........................................ 15
   4.2. Indicators to track the achievement of the strategic ambition .................... 16

References .................................................................................................................... 20

List of Working Group members .................................................................................... 24
Acknowledgements

To be included after the review process
Acronyms

CARE   Collective benefit, Authority to control, Responsibility, Ethics

FAIR   Findable, Accessible, Interoperable, Reusability

GCF    Global Carbon Fund

GEF    Global Environment Fund

GEOTRACES An international programme which aims to improve the understanding of biogeochemical cycles and large-scale distribution of trace elements and their isotopes in the marine environment.

GIS    Geographic Information System

GO-SHIP Global Ocean Ship-Based Hydrographic Investigations Program

IAEA   International Atomic Energy Agency

IMOS   Integrated Marine Observing System

IOC    International Oceanographic Commission

IODE   International Oceanographic Data and Information Exchange

IPCC   Intergovernmental Panel on Climate Change

ODIS   Ocean Data and Information System

OBPS   Ocean Best Practices System

PAHs   Polycyclic Aromatic Hydrocarbons

POPs   Persistent Organic Pollutants

SIDS   Small Island Developing States

SROCC Special Report on the Ocean and Cryosphere in a Changing Climate

UN     United Nations

UNEP   United Nations Environment Programme

UNESCO United Nations Scientific, Education and Cultural Organization

WESR   World Environment Situation Room

WOA    World Ocean Assessment
1. Executive summary

1.1. Overview of the Ocean Decade Challenge

Marine pollution constitutes one of the greatest threats to the marine environment, its ecosystems and the ecosystems services on which humans depend for climate regulation, food, coastal protection, employment, recreation, and cultural and physical well-being. The ever-increasing range of pollutants includes a multiplicity of substances and energy forms ranging from chemicals to oil, industrial effluents, biological contaminants and beyond. A threat in its own right, marine pollution also compounds the adverse impacts from other environmental threats, reducing ecosystem resilience to over-exploitation and climate change.

Despite the ocean’s importance to us, our understanding of marine pollution, its sources and impacts remains limited. Existing knowledge focuses predominantly on coastal areas in developed countries, with significant gaps existing in our understanding of baseline concentrations, additive effects, and long-term impacts at the local, regional and global levels. As nations seek to expand their blue economies, the challenge is to balance sustainable ocean use with protection. A collective and proactive approach is essential to minimize pollution sources and mitigate their impacts in order to safeguard marine ecosystems and ecosystem services, global food security, and human health, and to ensure sustainable development.

1.2. Key findings and recommendations

The strategic ambition of this challenge is to achieve a cleaner and healthier ocean, free from the impacts of marine pollution. Achievement of this ambition requires effective utilization of existing data and the generation of new insights focusing on key pollutants, sources, pressures, and regions, particularly on heavily affected coastal areas and emerging pollutants, as a priority. A global network of strategically positioned sentinel sites for comprehensive pollution monitoring is necessary. Methodological improvements including the enhancement of data quality through strict protocols, lower detection limits, and integration of field and laboratory experiments are also needed, as are holistic approaches to considering interdependencies between biotic and abiotic systems across the land-ocean continuum. Databases designed for effective data storage, management, and sharing are crucial. Co-design of observing and monitoring networks involving diverse stakeholders to foster engagement with coastal, Indigenous, and marine-dependent communities will help reduce disparities in capacities between and within regions. Improvements and innovations are required to develop cost-effective, real-time monitoring systems and to scale up technologies for tracing pollutant sources, distribution, and transfers across ecosystems. Efficient systems to prevent pollutants from entering oceans in the first place require the development, implementation and enforcement of rigorous waste management policies. Other recommended measures
include: the generation of a global marine pollution census; equity in data availability between the Global North and South; production of global maps of marine pollution; increased investments in pollution control programs; and development and implementation of global database infrastructure.

This White Paper provides a strategic framework for concerted global efforts in the UN Ocean Decade to address marine pollution comprehensively. Success will be measured through milestones and indicators focusing on environmental impact, data accessibility, knowledge sharing, capacity building, policy implementation, stakeholder engagement, funding, diversity, technology, and knowledge utilization. The integration with other Ocean Decade Challenges ensures a unified and holistic approach to safeguarding the oceans for future generations.

2. Introduction

2.1. Background and context of the Challenge

The ocean and its ecosystems provide significant benefits to humans including climate regulation, food, coastal protection, employment, and recreation, as well as cultural and physical well-being (IPCC, SROCC, 2019). However, the marine environment is under increasing threat from the cumulative negative impacts of human activities. Many ocean and coastal ecosystems are severely degraded and in need of immediate remedial action (UN, WOA I, 2015; UN, WOA II, 2021). One of the primary causes of this degradation is marine pollution.

Marine pollution is defined by the 1982 United Nations Convention on the Law of the Sea (Art 1(4)) as ‘the introduction by man, directly or indirectly, of substances or energy into the marine environment, including estuaries, which results or is likely to result in such deleterious effects as harm to living resources and marine life, hazards to human health, hindrance to marine activities, including fishing and other legitimate uses of the sea, impairment of quality for use of sea water and reduction of amenities’. The intrinsic quality of the substance or energy is not what matters. Any substance or energy emanating from any source (i.e., terrestrial, marine or atmospheric) may be a potential pollutant. Rather, it is the actual or potential impact that the introduction of a substance or energy has on marine biota and ecosystem services and functions that matters.

A wide array of substances and forms of energy are now recognized as marine pollutants, including, for example:

- chemicals, such as metals, radionuclides, persistent organic pollutants (POPs), fertilizers, pharmaceuticals, and polycyclic aromatic hydrocarbons (PAHs);
- oil and other petroleum-based products such as plastics;
- industrial and domestic effluents, as well as mine tailings and agricultural runoff;
biologically active substances, such as excessive nutrients, fecal bacteria, pathogens, and antimicrobial resistant bacteria;

- suspended sediments;
- light and noise.

While the above examples include some of the thousands of substances and energy sources in use, they do not encompass the entire spectrum of actual and potential pollutants, many of which may cause environmental impacts years after their introduction into the environment.

Currently, scientific knowledge of the sources and impacts of marine pollution on the marine environment remains limited (UN, WOAll, 2021; IOC-UNESCO, State of the Ocean, 2022). For deep ocean areas, in particular, our understanding of marine pollution is almost non-existent. Knowledge of marine pollution is primarily focused on coastal marine areas in developed countries (Global North) (Hatje et al., 2021), consistent with their well-established research capabilities and capacities, and typically addresses a limited number of pollutants, such as POPs, trace elements like mercury, and nutrients. In addition, despite current efforts, a lack of water and sediment quality criteria for substances of emerging concern (e.g., nanoparticles, rare earth elements) impedes the assessment of their ecological and human health risks (Arienzo, et al., 2022; Piarulli et al., 2021; Neira et al., 2022; Malhotra et al., 2020). Furthermore, limited information is available regarding the additive and cumulative effects of different pollutants as well as their impacts in the context of climate change (Hatje et al., 2022). Compounding the limitations of our existing knowledge are a lack of harmonization of methods for studying marine pollution and marked variations in the availability of quality assurance and quality control information for these types of data among different types of pollutants (UNEP, 2021; Schwesig et al., 2011; Jack et al., 2020). Limited knowledge of baseline concentrations of pollutants and a paucity of long-term studies further hampers our ability to assess temporal trends, differentiate between natural and human-induced stressors, evaluate the long-term impacts of pollution, and assess the effectiveness of regulatory measures.

Addressing these knowledge gaps is crucial to the production of knowledge, expertise, and research capabilities aimed at enhancing our understanding of marine pollution and its cumulative, long-lasting effects on human health and ecosystem functioning (Hatje et al., 2021). Achieving this objective requires coordinated efforts, reliable funding, enhanced availability of quality data following the FAIR principles (Findable, Accessible, Interoperable, and Reusability), harmonized methodologies, and the establishment of representative and sustainable long-term monitoring sites located in diverse marine environments and regions. Equally crucial is the necessity to present and communicate this knowledge in a format that is relevant, digestible, and transferable to all ocean users (Kelly et al, 2021), contributing to overall ocean literacy. Achieving this effort should be the result of a multi-stakeholder partnership aimed at bridging the science-policy gap,
thereby supporting informed decision making that ensures long-term ocean health and sustainability. This paper outlines several strategies to meet this goal.

2.2. Overview of current work in the Ocean Decade

Challenge 1, ‘Understand and beat Marine Pollution’, aims to understand and map land, air, and sea-based sources of contaminants and their potential impacts on human health and ocean ecosystems and to develop solutions to remove or mitigate them. As of November 2023, 3 Programmes, 26 Projects, and 4 Contributions (collectively ‘Actions’) are directly focused on addressing Challenge 1, although the issue of marine pollution may also be addressed either directly or indirectly by other Actions such as those aimed at ocean observing, prediction, and data sharing. Nevertheless, much work remains to be done. Notably, Challenge 1 is significantly under-represented at the Programme and Contribution level, with many Projects categorized under Challenge 1 existing as ‘orphan’ projects, lacking any association with any coordinated programme. Moreover, while Asia, Europe, and North America are well-represented at the Programme level, there is a lack of Programmes in other regions and, at the Project level, major gaps exist, particularly in the Latin America and Australia/Pacific regions, with no representation of Small Island Developing States (SIDS) to date.

Substantively, Actions currently focus broadly on three thematic areas: acoustic/noise pollution, plastic, and organic pollution. Actions dedicated to addressing acoustic/noise pollution primarily focus on the creation of datasets, the advancement of knowledge about impacts of underwater noise on fish and invertebrates, and the development of innovative listening and monitoring technologies for detection and assessment. Not addressed are issues of knowledge exchange and capacity development. Plastic pollution is addressed only at the Project level, with no specific overarching or coordinating Programme dedicated to addressing the issue. Projects within this domain focus on the development of datasets on the distribution of plastic waste, the development of greater understanding of its impacts, and the establishment of necessary infrastructure, including capacity-building initiatives to assist countries in developing sound management solutions for plastic waste. Despite these efforts, critical aspects such as partnerships, resource allocation, and a comprehensive approach to addressing plastic pollution at its source are not adequately addressed within these Projects. Similarly, while some Actions tackle issues such as freshwater pollution and organic contamination, there are no Actions explicitly focused on nutrient pollution and there is little focus in these Actions on aspects such as infrastructure development, partnerships, development of best practices and resource allocation.

These gaps highlight the need for additional Actions – particularly at the comprehensive Programme level – that specifically and more cohesively address the various aspects of Challenge 1 at local, regional, and global levels.
2.3. Importance and relevance of the Challenge for sustainable development

To ensure a sustainable future, we must recognize that marine pollution stands as one of the most serious threats to the ocean, both directly and as a multiplier, which reduces the resilience of marine ecosystems to respond to other threats such as climate change. Reducing and mitigating marine pollution helps safeguard marine biodiversity, global food security, natural resources, and ecosystem as well as cultural services. Achieving sustainable development therefore requires collective and proactive actions to minimize and/or eliminate pollution sources and mitigate its impacts on ecosystem and human health and well-being. Moreover, as countries seek to develop and to sustainably expand their blue economies, the possibility exists that this ‘blue acceleration’ will introduce new and different forms of marine pollution. The societal challenge is to develop integrated and coordinated cross-sectoral approaches that balance the sustainable use of the ocean with its protection (Rayfuse, Klein and Jaeckel, 2022).

2.4. Methodology for strategic ambition setting

This work was developed by gathering information from various sources, including responses to a questionnaire from members of this working group, consultations with specific target groups (such as professional networks and UN agencies), online meetings, public webinars, and a review of relevant scientific literature.

3. Strategic ambition setting

3.1. Analysis of user needs and priorities

The science, data and infrastructure needs and priorities of the wide range of users throughout the entire marine pollution value chain are formulated according to their different interests, purposes, roles and mandates, and are subject to change over time. This reflects the dynamic and evolving state of ecosystems and their connection to human activities, which is the outcome of interactions across spatial and temporal scales.

Improving the quality, coverage, and availability of data about the state of the ocean, the pressures affecting it and their causes, is essential for informed governance of the marine environment and the socio-economic activities it supports. High-quality data supports science-based decisions, enabling the informed prioritization of tailored policies, managerial measures, technical solutions, as well as public and private investment decisions. Moreover, it fosters trust among users, creating entry points of cooperation or strengthening existing cooperation (Cvitanovic et al., 2021). The generation and management of reliable data and information are particularly important when applying management approaches that address the multi-layered challenges that transcend geographical scales across borders and span environmental components (i.e., biosphere, lithosphere, hydrosphere, atmosphere), economic sectors, and management sectors (Granit et al., 2017; Lucca et al., 2023).
For the purposes of this paper, a classification of users and uses of data, can guide efforts to define needs in terms of knowledge, as well as the means to acquire data and manage them:

- **The scientific community** is working to better understand and generate knowledge on pollution sources, cycling, interactions, and impacts on ecosystems, human health, and the socio-economic issues related to marine pollution which should be used to inform the management of ecosystems across the source to sea continuum.

- **Government agencies** at local, regional, national, and international levels need to collaborate with scientists to assess the impact of pollution along the land-marine continuum, develop policies, legislation and management plans, and implement/enforce compliance. These instruments may focus on pollution prevention and control or on the management of the environmental components affected by pollution.

- **The private sector** should promote sustainability of its business by ensuring compliance with regulations and implementing measures throughout its supply chains to reduce its environmental footprint. This includes robust environmental impact assessments of planned blue economic operations and disclosure, by businesses and investors, of the impact of their operations on the environment which in turn requires independently verified and detailed data about the impact of individual businesses, industry sectors and investment portfolios on marine pollution.

- **Civil society** needs to better understand the causes and effects of pollution to effectively contribute to the dialogue for sound governance of the marine environment, enabling transparency, awareness, and action.

- **The general public** must raise awareness of the sources and effects of pollution on human and environmental health, making informed consumption choices and advocating for, and adopting, pollution reduction measures.

The challenge now is to fill the knowledge gaps and to quantify the extent of impacts of marine pollution on human and ecosystem health to provide a sound knowledge base from which preventive and mitigative measures can be best designed and implemented for the benefit of all users.

### 3.2. Definition of the strategic ambition for the Challenge

Our strategic ambition is to achieve a cleaner and healthier ocean, where all ecosystems and their inhabitants thrive free from the impacts of marine pollution allowing for their full functioning and service provision. To achieve a clear and cohesive understanding of marine pollution, its implications for both human and ocean health, and effective solutions,
we must forge connections among scientists, the private sector, the broader civil society, and governmental agencies/policymakers. Collaboratively, we must actively seek funding to address the existing knowledge and data gaps that currently impede informed decision-making, thereby ensuring the sustainable development of the ocean. The challenge ahead involves decreasing the release of pollutants into the marine environment, with a view to controlling, mitigating and ultimately preventing marine pollution. This necessitates prioritizing the study of the most impactful current and emerging pollutants, the adverse effects of which are not yet fully understood.

To accomplish this, it is crucial to establish baseline databases and conduct long-term studies that enable the continuous monitoring of ocean health and the impacts of marine pollution. A key aspect of this effort involves leveraging the involvement of all users and amplifying the voices of coastal communities, marine-dependent populations, and Indigenous communities, who are often overlooked but who are the most affected by marine pollution. Capacity building and the development of easily accessible databases and summary reports are imperative for efficient sharing of information and informed decision-making in our pursuit of combating marine pollution. Access and transfer of technologies, particularly to those most affected, will also be key to overcoming the marine pollution challenges.

Our first priority is to address data gaps related to the sources and impacts of priority pollutants (e.g., pollutants found in high concentrations, or with high toxicity, or with known adverse effects on biota or human health) and the most contaminated areas. To evaluate temporal trends and evaluate the effectiveness of control and remediation actions, we need to implement representative sentinel sites worldwide for long-term studies. Our second priority is to compile these data into standardized and interoperable regional and global databases, based on common best practices for data collection and management, that are freely available and accessible, facilitating the sharing and comparing of information and supporting better decision-making. Our third priority should be capacity building to help bridge the data gap between the Global North and the Global South, fostering the development and sharing of knowledge and technological solutions to mitigate marine pollution. These priorities are described in more detail below.

### 3.2.1. Priority datasets

To tackle marine pollution, it is essential to map and leverage existing data, while generating new knowledge on pollutant distribution, cycling and their impacts on ecosystems and human health. Existing datasets are scattered across various platforms, making data mapping complex due to varying methodologies and quality control protocols, among other factors. However, acknowledging and recognizing these datasets can prevent redundancy and streamline priorities. The following three-step roadmap addresses these challenges.
• **Prioritization of areas, pressures and pollutants.** Pollutants affect almost all environments to varying degrees, necessitating prioritization in terms of the types of pollutants, sources, pressures and regions to be monitored. Priority should be given to monitoring, reporting, sharing information, and mitigating well-known pollutants (e.g. mercury, POPs, plastics) that can harm wildlife, ecosystem services, threaten food security and human health, and point-source pressures (e.g. areas with fishing activity, artificial structures and resource extraction) that alter ecosystems, often in a negative way and may be linked to pollutants. Focusing on heavily polluted coastal areas, particularly those with marine resource dependent and Indigenous communities, is imperative. In addition, an increasing number of emerging pollutants and pressures are being detected in marine environments though their impacts are yet unclear. We must evaluate pollution impacts and emerging pressures, and monitor historically neglected regions, many of which are in the Global South. Finally, expanding research and monitoring of pollutants and pressures in the open and deep ocean is essential.

• **Long-term time series datasets.** Long-term datasets enable the identification of baseline conditions and temporal trends, helping to disentangle natural variability from anthropogenic change. Additionally, they allow the evaluation of the effectiveness of regulatory actions. To expand databases, the establishment of physical structure and capabilities to develop long-term monitoring data in strategic positioned sentinel sites around the world will be critical (see Infrastructure requirements in s. 3.2.3 below).

• **Global, regional and national databases.** Coordinated databases housing datasets for priority pollutants already affecting human health and ecosystems and considering emerging pollutants should be established at national, regional, and global levels to become a valuable resource for scientists, environmental authorities, consultants, and any other interested users. These databases should adhere to the FAIR and CARE (Collective benefit, Authority to control, Responsibility, Ethics) principles and ensure data consistency and comparability by following harmonized procedures ensuring best practices for sample collection, analysis, quality control, data storage, data management, and data reporting and sharing (see, e.g., CoreTrustSeal; Ocean Best Practices System (OBPS); IMOS).

### 3.2.2. Knowledge generation and sharing

To gain a comprehensive understanding of marine pollution, its impacts, and the necessary steps to mitigate and manage it effectively, the following issues need to be addressed:

• **Methodological improvements.** High-quality data is paramount for enhancing the development and application of predictive models to better understand and anticipate pollutants behavior and impacts. To reduce methodological biases, and
ensure reproducibility, accuracy, and precision to address environmental and societal challenges, laboratories should follow strict quality control protocols (e.g., GEOTRACES cookbook). Laboratories are encouraged to report data on certified reference materials or consensus intercalibration samples and to participate in proficiency tests. In addition, there is a need to lower the analytical limits of detection of pollutants and to integrate field and laboratory experiments at various spatial and temporal scales, considering the co-occurrence of multiple contaminants. Particular attention should be paid to improving countries’ ability to comply with such protocols, which will not be effective without appropriate capacity and trained researchers.

- **Holistic approach.** The complex interrelationships between biotic and abiotic systems across the land-ocean continuum require the use of holistic approaches to the understanding and assessment of pollutant sources and pathways as well as to the evaluation and mitigation of pollutant impacts. These approaches should encompass human and ecosystem health, as well as ecosystem services and functions within their respective social and environmental contexts.

- **Data sharing.** To enable informed decisions and prioritize mitigation actions, it is essential to leverage marine pollution data and ensure free and easy access to quality information. To enhance the comprehensibility of marine pollution issues for policymakers, private sectors, civil society and the general public, information derived from marine pollution monitoring, modeling, and mitigation efforts should be consolidated in regional, national, and global synthesis reports, as well as in easily accessible online visual resources (e.g., IPCC regional and sectorial fact sheets). An Ocean Literacy strategy focused on marine pollution should be developed locally, considering relevant contexts and realities (i.e., ODIS and/or Ocean Literacy Portal of UNESCO). Citizen science, diverse visual products, and media should be developed and utilized to communicate the lessons learned from monitoring and mitigating marine pollution, while engaging the public in addressing this environmental challenge.

### 3.2.3. Infrastructure requirements

Establishing adequate infrastructure is essential for monitoring marine pollution and for data-knowledge generation and sharing. The unequal distribution of ocean monitoring infrastructure leads to uneven geographical data collection and knowledge gaps (Tolochko and Vadrot, 2021; Bax et al., 2018; Hatje et al., 2021).

To expand datasets, the establishment of long-term ocean monitoring sentinel sites, akin to the Mauna Loa station for atmospheric CO₂ measurements (known as the Keeling Curve (Keeling et al., 2001; Keeling and Keeling, 2017)) is of paramount importance. These sentinel sites should adopt harmonized methodologies and be strategically located in representative areas to form a comprehensive monitoring network that can monitor the
global extent of marine pollution, encompassing its wide regional variability (Cooper et al., 2023), from the most pristine to the heavily polluted areas.

The establishment of regional laboratory hubs, observatories, and platforms is pivotal for understanding and mitigating marine pollution. These facilities should provide the necessary infrastructure and skilled teams to promote training, facilitate data generation, management, and sharing regional databases on integrated platforms while upholding the FAIR principles.

Future global monitoring initiatives should mobilize researchers worldwide to study and monitor marine pollution using standardized methods and best available techniques. These initiatives are crucial for making meaningful global comparisons, for democratizing infrastructure access (for example, to expand the utilization of nuclear/isotopic techniques for fingerprinting and determination of contaminant transfers along food webs), and for assessing contaminant fluxes over time. These initiatives will help to reveal the global pollution status, identify pollution hotspots and pollutants of concern, and help to develop effective control and mitigation strategies by sharing best practices among stakeholders. This infrastructure should be modeled on successful program-based initiatives, such as GO-SHIP, GEOTRACES, the IAEA-Technical Cooperation Program, and initiatives established under the Regional Seas conventions, among others. Consideration should also be given to establishing regional and global infrastructure, including partnerships and funding mechanisms that can be rapidly mobilized in the event of accidental pollution incidents, such as oil spills or radioactive releases.

Infrastructure for a global, proactive, and publicly available database and data archiving system is necessary to increase transparency and knowledge sharing, particularly where harmonized sampling and analytical methods have been used. Funding will be necessary to establish the database infrastructure compatible with the Global Information System (GIS) and for its maintenance. This infrastructure will facilitate the automated creation of maps for global pollution monitoring data with minimal effort in the future. The responsibility for and coordination of such database infrastructure should reside within the UN system with the IOC-UNESCO, possibly through the International Oceanographic Data and Information Exchange - IODE.

### 3.2.4. Partnerships and resources

The complexity and transboundary nature of marine pollution necessitate the development of partnerships on a range from local and regional, to international scales (Polejack, 2021). These collaborations should strategically leverage resources and expertise, drawing upon and updating existing national, regional, and international strategies and action plans. Decade Collaboration Centres as well as organizations and institutions such as IOC-UNESCO and the UNEP Regional Seas Programme could play
a facilitative role in maintaining continuous communication among diverse stakeholders and promoting the application of collected data.

To understand and beat marine pollution effectively it is essential to co-design ocean observing and pollution monitoring networks in partnership with a diverse range of users, including scientists, governments, non-governmental organisations, private sectors, Indigenous, and marine resource dependent communities (Bax et al., 2018). This collaborative effort must aim to educate, instill ownership, and enhance public participation, in order to foster understanding of the impacts and solutions for mitigating marine pollution. In some instances, coastal, Indigenous and marine resource dependent communities are ideally positioned to observe coastlines and ecosystems, alert authorities to pollution impacts, engage with local decision-makers, and contribute to generating knowledge and data tailored for effective pollution mitigation.

To ensure the inclusion of local perspectives, needs, and priorities in the evaluation and mitigation of pollution, it is necessary to use existing bodies and institutions at regional level, in addition to national or international ones. Strategic partnerships, both at the national and international levels, should be sought to leverage financial mechanisms and expertise. This includes the establishment of sustainable funding systems to address marine pollution issues, drawing on resources from entities such as the United Nations (e.g., Global Environmental Facility-GEF and Green Climate Fund-GCF), the private sector, and philanthropy. Furthermore, the formation of multilateral donor partnerships is essential for comprehensive and effective solutions.

3.2.5. Capacity development and exchange needs

The key principles for the capacity development component of marine pollution are engagement, justice, and co-design (Bennet, 2018; Norström, et al., 2020). Two important aspects should be highlighted within capacity development: the disparities in capacities between the Global South and the Global North, and the widespread lack of participation by local communities in data generation and sharing. Consequently, there is a need to foster engagement with coastal, Indigenous, and marine resource-dependent communities, with a specific focus on involving scientists and community members from Global South countries, Least Developed Countries and SIDS in research activities and decision-making processes.

A just capacity development component acknowledges and respects the unique needs of each community, comprehends their perspectives, and seeks to address the knowledge gaps identified not only by scientists, but also by the communities themselves. Strategies and joint action plans should align with user needs, benefiting those reliant on the ocean. (Harden-Davies, 2016; Harden-Davies et al., 2022).

Top priorities for training and exchange programs should focus on disseminating harmonized methods for data consistency, offering comprehensive training covering
environmental sampling, pollutant biogeochemistry, and fostering collaboration between developed and developing nations for pollution measurement and remediation.

International scientific cooperation and technology transfer are pivotal for efficient capacity development. Ocean science diplomacy can bridge policymakers and researchers, creating evidence-based international regulations on marine pollution (Polejack, 2021).

The aim of this capacity development framework is to bridge user gaps and promote successful pollution control stories and ecosystem recoveries, prioritizing society’s involvement. Engaging policymakers, early career ocean professionals, and youth aligns with Ocean Literacy principles and aims to include marine pollution topics in school curricula. Initiatives like the blue school (Costa et al., 2021), Ocean Teacher Global Academy (Claudet, et al., 2019) and World Ocean Day (https://worldoceanday.school/resources-2020/) further this goal, sharing best practices and promoting technology transfer among countries.

### 3.2.6. Technology and innovation solutions

To bridge global marine pollution knowledge gaps, a range of innovative technological and practical solutions are essential, including:

- **Autonomous monitoring systems**: Develop cost effective, reliable, globally deployable techniques (e.g., sensors) for fast, real-time, and affordable water quality and contaminant assessments. Encourage citizen science participation in their maintenance and deployment.

- **Analytical techniques**: Scale up mass spectrometry, nuclear, isotopic, and emerging technologies to trace pollutant sources, distribution, and transfers across food webs, including humans.

- **Widespread wastewater treatment**: Create cost-effective and efficient systems to prevent pollutants from entering oceans.

- **Sustainable practices**: Innovate sustainable practices within industries like farming, fishing, shipping, mining and oil and gas industries to minimize their impact on marine environments.

- **Clearing-house mechanism**: Implement a clearing house mechanism, i.e., a network of parties and partners working together, for the transfer of marine technology specifically focused on addressing pollution (see, e.g., IOC-UNESCO, 2005; Polejack and Coelho, 2021).

- **Innovative education tools**: Use narrative storytelling, games/Apps, technology-driven awareness campaigns, and platforms like UNEP’s World Environment Situation Room (WESR) to raise awareness and influence positive behavioral changes in communities, policymakers, and industries.
3.3. Integration, synergies and interdependencies with other Challenges

Reducing, preventing, and mitigating marine pollution requires a holistic approach to ocean management which considers the full range of complex interrelationships between biotic and abiotic systems across the land-ocean continuum. This approach is mirrored in the interdependency between several, if not all, of the Ocean Decade Challenges. Achieving the objectives of Challenge 2, ‘Protect and Restore Ecosystems and Biodiversity’ and of Challenge 3 ‘Sustainably Feed the Global Population’ is not possible without achieving the objectives of Challenge 1. Similarly, the objectives of Challenge 5, ‘Unlock Ocean Based Solutions to Climate Change’ must only be achieved in a manner that is consistent with the goals of Challenge 1. Particular synergies exist with Challenge 7, ‘Expand the Global Ocean Observing System’ and Challenge 8, ‘Create a Digital Representation of the Ocean’, the achievement of both of which will be important to the achievement of Challenge 1. Challenge 10 ‘Change Humanity’s Relationship with the Ocean’ which deals with the concept of Ocean Literacy, is key to helping raise awareness of the marine pollution issue and contributing to fostering positive behavioral changes within communities, policymakers, and industries. Finally, capacity development and equitable access to data, information and technology, the objective of Challenge 9, ‘Skills, Knowledge and Technology for All’, is of central importance to addressing Challenge 1. Coordination of and between all these Challenges will be critical to ensuring the necessary tools, infrastructure and services are in place to deliver the objectives of Challenge 1.

4. Milestones and indicators

4.1. Key milestones to measure progress and success

The overarching objective of this Challenge is to attain, by 2030, pollution levels that do not jeopardize human health or disrupt ecosystem services, aiming to maintain pollutant concentrations near background levels for naturally occurring hazardous substances and close to zero for human-made hazardous substances. Essential milestones to gauge our progress within distinct time frames include:

- **Milestone 1. Societal and Environmental Impact.** Improved health of marine ecosystems affected by pollution, including ecosystem function, biodiversity and interdependencies with climate change; reduced impacts on human health; and reduced vulnerability of coastal communities and ecosystems to marine pollution and economic impacts.
- **Milestone 2. Enhanced Ocean Data Accessibility and Availability.** Increased availability and accessibility of ocean data relating to marine pollution, including the streamlining of data-sharing platforms, standardized data formats, and open access policies.
• Milestone 3. *Advancement in Ocean Knowledge Sharing.* Increased generation and sharing of scientific knowledge and information related to the causes, impacts, and minimization of marine pollution.

• Milestone 4. *Building Capacity for Understanding and Beating Marine Pollution.* Increased capacity of individuals, institutions, and communities to effectively address the causes and impacts of marine pollution, and to monitor and minimize its impacts in both the short term and for the long term.

• Milestone 5. *Sustainable Policy and Governance Implementation.* Increased development and implementation of policy and governance frameworks that support sustainable ocean management and the control, prevention, and minimization of all forms of marine pollution from all sources (i.e., terrestrial, marine, and atmospheric).

• Milestone 6. *Inclusive Stakeholder Engagement.* Increased, inclusive, diversified, equitable, and meaningful stakeholder engagement and participation in ocean observing and in marine pollution monitoring networks.

• Milestone 7. *Increased Funding for Decade Actions Tackling Marine Pollution.* Increased funding for the implementation of Decade Actions addressing marine pollution and the establishment of sustainable financial mechanisms to support their long-term implementation, even beyond 2030.

• Milestone 8. *Diverse and inclusive Decade Actions.* Increased diversity and inclusivity of Decade Actions targeting marine pollution with particular reference to currently under-represented topics and/or geographical regions.

• Milestone 9. *Advancement in Ocean Technology and Innovation.* Increased advancement in ocean technology, innovation, and infrastructure to support research relating to marine pollution and its control, prevention, and minimization.

• Milestone 10. *Enhanced Utilization of Ocean Science and Knowledge.* Increased use of ocean science and knowledge to educate, raise public awareness, improve transparency, understanding, decision-making, and governance of the causes and impacts of marine pollution and the sustainable management of the ocean.

4.2. **Indicators to track the achievement of the strategic ambition**

• Milestone 1. *Societal and Environmental Impact*  
Indicator 1.1: By 2030, significant improvements in water quality, biodiversity and ecosystem services and functions in estuarine, coastal and marine ecosystems indicated as a reduction in impacts on the environment, human health and economic life, as evidenced by decreases in emissions and discharges of pollutants into the ocean including:
  - reduction from current levels in produced and displaced wastewater discharge;
  - reduction from current levels in dispersed oil discharge;
- reduction from current levels of discharges of artificially and naturally occurring radionuclides from the nuclear and non-nuclear sector (e.g., oil and gas activities);
- reduction from current levels in floating and accumulated litter and plastics in marine and terrestrial ecosystems;
- reduction from current levels of deposition into the ocean of hazardous substances and increase in adoption and use of less hazardous substances.

Indicator 1.2: Completion of comprehensive assessments of the interplay between pollutants and climate change, examining their combined impact on marine ecosystems and biodiversity.

Indicator 1.3 Implementation and enforcement of more rigorous global and local waste management policies, cleaner industrial processes/technologies and a better sanitation index.

Indicator 2.4: Identification of key contaminants thresholds risks (environmental, social and economic endpoints) focusing on impact to assess global ocean health.

- **Milestone 2. Enhanced Ocean Data Accessibility and Availability**
  Indicator 2.1: Development, by 2030, of interoperable, open and accessible global marine pollution baseline datasets that encompass various pollutants, including contaminants of emerging concern, while adhering to the FAIR and CARE principles
  Indicator 2.2: Development, adoption and implementation of harmonized protocols for collecting, treating, and ensuring completeness, timeliness and quality of data generated on actual and potential pollutants and their impacts on the marine environment and human health.
  Indicator 2.3: By 2028, establishment of sentinel sites for long-term monitoring of marine pollution across the globe.
  Indicator 2.4: Improved incentives for data-sharing and the creation of enabling conditions for data-sharing.

- **Milestone 3. Advancement in Ocean Knowledge Sharing**
  Indicator 3.1: Creation of inventories of pollution sources identified on national/regional scales by 2030.
  Indicator 3.2: Production of regional and global maps of marine pollution.
  Indicator 3.3: Conduct of a global ocean pollution assessment and action plan, to be completed by 2030 and updated every five years, in collaboration with diverse stakeholders such as scientific institutions, government agencies, NGOs, private sector entities, traditional communities, and other users.
  Indicator 3.4: Amplification of the voices of coastal, marine-dependent, and Indigenous communities within Decade Actions targeting marine pollution.
Indicator 3.5: Development of an Ocean Literacy strategy for marine pollution, adapted to local contexts and languages and including issues of Citizen Science and Science Communication.

- **Milestone 4. Building Capacity for Understanding and Beating Marine Pollution**
  Indicator 4.1. Establishment of training and capacity building programs focused on disseminating harmonized methods to support of sound data generation, management, and sharing of regional databases.
  Indicator 4.2: Establishment of regional marine pollution laboratory hubs/observatories for monitoring, training and data sharing.

- **Milestone 5. Sustainable Policy and Governance Implementation**
  Indicator 5.1: Implementation of existing and development of new international policies and instruments, based on best practices globally, targeting marine pollution considering its environmental and socio-economic impacts.
  Indicator 5.2 Development of coordination mechanisms and structures at country level, among sectors and governance levels across the source to sea continuum including basins, aquifers, coastal zones and marine areas.
  Indicator 5.3: Adoption of indicators or thresholds, similar to the IPCC framework, for assessing the severity of the different contaminants in the environment (e.g., the evolution of the input contaminants - similar to work undertaken for CO\textsubscript{2} in the atmosphere) and mechanisms for the adoption and use of these indicators at the national level.
  Indicator 5.4: Evaluation of the effectiveness of current policies, development and implementation of policy indicators to monitor the evolution of laws and regulations towards effective actions and solutions.

- **Milestone 6. Inclusive Stakeholder Engagement**
  Indicator 6.1: Implementation of tracking process parameters as milestones within participating countries, institutions, commitments, projects, funding initiatives, and scientific publications.
  Indicator 6.2: Promotion and establishment of collaborative partnerships at the local, national, regional and international levels, involving users across the public, private and civil society spectrum and aimed at reducing, controlling, minimizing and mitigating marine pollution
  Indicator 6.3: Promotion of sustainable practices within the private sector.
  Indicator 6.4: Implementation of a platform (such as UNEP, World Environment Situation Room (WESR)) to present and project information on marine pollution to decision makers.
• **Milestone 7. Increased Funding for Decade Actions Tackling Marine Pollution**
  Indicator 7.1: Upscaling of investments and development of innovative partnerships to acquire funding for Decade Actions focusing on marine pollution.
  Indicatory 7.2: Development of conditions and innovative mechanisms and partnerships to encourage private and non-sovereign capital to invest in and fund implementation of marine pollution study, reduction and mitigation beyond 2030.

• **Milestone 8. Diverse and inclusive Decade Actions**
  Indicator 8.1: Establishment of new coordinated Decade Actions, particularly at the Programme level, focusing specifically on the ongoing evaluation and monitoring of pollution impacts on marine ecosystems and human health in under-represented geographical areas, including Latin America, SIDS, and the Pacific.
  Indicator 8.2: Improved equity in data availability and knowledge between the Global North and the Global South

• **Milestone 9. Advancement in Ocean Technology and Innovation**
  Indicator 9.1: Development of new, robust, readily accessible, cost-effective, measuring, screening and monitoring technologies that are easy to use and maintain.
  Indicator 9.2: Development, particularly in LDCs, of the human know-how and capacity to employ best available technologies.
  Indicator 9.3: Development of a clearing-house mechanism for the transfer of marine technologies devoted to pollution.

• **Milestone 10. Enhanced Utilization of Ocean Science and Knowledge**
  Indicator 10.1: Development and implementation of indicators to track progress in reducing knowledge and data gaps across the globe.
  Indicator 10.2: Planning, design and implementation of a global database infrastructure within the UN system.
  Indicator 10.3: Developing indices and communication strategies for policy makers and other users to articulate the impacts of marine pollution and pollutants in terms of environmental, human and economic consequences to close the science-policy gap.
  Indicator 10.4: Development and conduct of a comparative analysis of quantitative data (marine pollution stock-take) to evaluate the current status of the ocean health and measure the impact of interventions over specific intervals, such as 5 or 10-year periods.
References


Care Principles for Indigenous Data Governance https://www.gida-global.org/care


GEOTrACES (2017), Sampling and Sample-handling Protocols for GEOTrACES Cruises, https://www.geotraces.org/methods-cookbook/


UN, WOAI (2015), The First Global Integrated Marine Assessment, World Ocean Assessment I
UN, WOAI (2021), The Second World Ocean Assessment, Ocean Assessment II
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United Nations Decade of Ocean Science for Sustainable Development (2021-2030)

Proclaimed in 2017 by the United Nations General Assembly, the UN Decade of Ocean Science for Sustainable Development (2021-2030), provides a convening framework to develop the scientific knowledge and partnerships needed to catalyse transformative ocean science solutions for sustainable development, connecting people and our ocean. The Ocean Decade is coordinated by UNESCO’s Intergovernmental Oceanographic Commission (IOC).

Established during the Preparatory Phase and to continue throughout implementation until 2030, the IOC’s Ocean Decade Series will provide key documentation about this global initiative and aims to serve as a primary resource for stakeholders seeking to consult, monitor and assess progress towards the vision and mission of the Ocean Decade.

https://oceandecade.org/