GESAMP Contributions to and Role in the Global Decade of Ocean Science

1 Introduction

In December 2017, the United Nations General Assembly (UNGA) declared the decade of 2021-2030 as the UN Decade of Ocean Science for Sustainable Development ("the Decade"). There have been a number of important United Nations (UN) initiatives in ocean affairs and marine environmental protection. The Decade, however, is arguably the first to specifically focus on enhancing the role of ocean science in support global sustainable development.

IOC-UNESCO was tasked to lead the UN-wide effort to plan and implement the Decade. In August 2020, IOC delivered the implementation plan for the Decade to the UNGA (https://oceanexpert.org/downloadFile/46072). In October 2020, the Decade Secretariat issued a Call for Decade Actions inviting organizations and activities to apply for endorsement as Decade activities. This process targeted entities outside the UN system, with UN entities following a separate process.

GESAMP and its sponsoring agencies agree that, as a joint mechanism of UN agencies with responsibilities for ocean affairs, it is important and appropriate for GESAMP to contribute as fully as possible to the Decade. As an early step, GESAMP agreed to map its ongoing activities against the goals of the Decade. This will clarify our understanding of how our current activities contribute to the Decade, and help us identify how to improve our contributions and plan future activities.

This document is a first step in that effort. It is organized around the structure of the implementation plan, which identifies seven desired outcomes.

- A clean ocean where sources of pollution are identified and reduced or removed.
- A healthy and resilient ocean where marine ecosystems are understood, protected, restored and managed.
- A productive ocean supporting sustainable food supply and a sustainable ocean economy.
- A predicted ocean where society understands and can respond to changing ocean conditions.
- A safe ocean where life and livelihoods are protected from ocean-related hazards.
- An accessible ocean with open and equitable access to data, information and technology and innovation.
- An inspiring and engaging ocean where society understands and values the ocean in relation to human wellbeing and sustainable development.

Clearly, these outcomes are strongly interlinked (e.g., a clean ocean contributes to a healthy and resilient ocean), but for each outcome the Implementation Plan provides detail and explanation that provides more focus (see Section 3.1). For example, while the clean ocean outcome focuses on pollution the healthy/resilient ocean outcome focuses on ecosystem processes and integrity.

The Decade implementation plan also identifies ten challenges that will need to be addressed to achieve the Decade outcomes, in three categories:

- Knowledge and Solutions Challenges.
- Essential Infrastructure Challenges
- Foundational Challenges

Section 3.2 lists the ten specific Decade Challenges, by category.

2 Mapping GESAMP's contributions to the Decade

This section analyses GESAMP's current work plan in the context of the Decade Outcomes, Challenges and Objectives. Most of GESAMP's substantive work is conducted by specialised Working Groups that conduct and report on studies on major topics of interest to its UN Sponsoring Agencies, often identifying knowledge gaps and recommendations for further research and good environmental management practices. Members of GESAMP and its Working Groups (WGs) serve in an independent scientific capacity, and not as representatives of governments or organizations. GESAMP's current work plan includes nine WGs working on an assortment of inter-related topics.

The following sections present the contributions of each WG to the Decade. The tables below summarise GESAMP Working Group activities/contributions with respect to Decade Outcomes and Challenges. More detail is provided for individual WGs in subsequent tables.

Decade Outcome	**GESAMP Working Group Contributions**
Clean Ocean	WG1, WG34, WG38, WG40, WG41, WG42, WG43, WG44, WG45
Healthy/Resilient Ocean	WG34, WG38, WG42, WG43, WG44, WG45
Productive Ocean	WG1, WG34, WG38, WG40, WG41, WG43, WG44
Predicted Ocean	WG38, WG42, WG45
Safe Ocean	WG1, WG34, WG40, WG43, WG44
Accessible Ocean	WG1, WG34, WG38, WG40, WG41
Inspiring/Engaging Ocean	

Decade Challenge	**GESAMP Working Group Contributions**
1, Understand/map sources of contaminants/pollutants	WG1, WG34, WG38, WG40, WG42, WG43, WG44
2.Understand effects of multiple stressors and develop solutions	WG41, WG44, WG45
3. Optimise fisheries sustainability	WG1, WG43, WG44, WG45
4. Solutions for sustainable blue economies	WG41, WG42, WG43, WG44
5. Understand ocean/climate nexus and build resilience	WG41
6. Multi-hazard early warning services	
7. Comprehensive, accessible ocean observing system	
8. Collaboratively develop a digital representation of the ocean	WG38
9. Capacity development and equitable access to information	WG34, WG38, WG40, WG41

10. Enhance society's understanding of the ocean and human well-being	WG40, WG41

2.1 Working Group 1: Evaluation of the hazards of harmful substances carried by ships

Terms of Reference for WG 1

1 The GESAMP Working Group on the Evaluation of the Hazards of Harmful Substances Carried by Ships is an expert group to provide best available scientific assessment of the environmental, occupational and safety hazards of chemicals, in particular to:

.1 Provide scientific advice on the hazards of chemicals transported by ships as may be requested, particularly by IMO;

.2 Evaluate safety data and test reports on specific chemicals submitted by industry in accordance with the rationale approved by GESAMP for this purpose and create a GESAMP Hazard Profile for such chemicals accordingly;

.3 Maintain a list of hazard evaluations ("Composite List" of GESAMP Hazard Profiles) for the use by IMO and keep it up to date based on available scientific data; and

.4 Observe the developments concerning the international harmonization of hazard classification by the United Nations and scientific guidance on hazard assessment published by international organizations to improve the GESAMP hazard evaluation procedure and GESAMP hazard ratings.

WG 1: EVALUATION OF THE HAZARDS OF HARMFUL SUBSTANCES CARRIED BY SHIPS			
Agency Sponsors	**Existing/Potential Partners**	**Activities/Delivery**	**Communications**
IMO	IMO's Marine Environment Protection Committee (MEPC) International regulatory bodies Shipping industry Chemical industry	Maintain comprehensive data on Toxicological, physical and chemical characteristics of substances carried in bulk by ships Regular expert meetings to evaluate information and assign hazard profiles to individual substances/mixtures From time to time, assess and revise as necessary the hazard evaluation procedure	Regular reports to MEPC Open-access publication of hazard evaluation procedure/criteria Open access of hazard profiles to industry

Decade Outcome	**Contributions**
Clean Ocean	GESAMP Hazard Profiles are used to determine conditions for bulk carriage of substances by ships to reduce risks of spills or other releases. They also provide important information on the substance characteristics that is useful in spill response and cleanup.
Healthy/Resilient Ocean	
Productive Ocean	Evaluation criteria include bioaccumulation/biodegradation and toxicity criteria relevant to both effects on fisheries stocks and seafood safety.
Predicted Ocean	
Safe Ocean	Hazard evaluation procedure includes criteria such as corrosion and flammability that are directly relevant to the safety of vessels at sea. A number of hazard evaluation criteria (e.g., human toxicity, carcinogenicity) address human health hazards to both vessel crew and other ocean users.
Accessible Ocean	The hazard evaluation procedure is freely available online, and the hazard profiles themselves are available to industry and online to the public. The evaluation procedure includes advice on biodegradation and environmental toxicity test methods for mixtures of substances that is relevant to other marine applications. The evaluation procedure includes examples on conducting hazard evaluation of mixtures of substances.

Inspiring/Engaging Ocean	
Decade Challenges	
Challenge 1: 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. Evaluation of the hazards of substances carried in bulk by ships, including potential effects on biota and human health, is an established component of existing management strategies to mitigate them. The evaluations are continually updated to reflect new data and new substances	
Challenge 3: Generate knowledge, support innovation, and develop solutions to optimise the role of the ocean in sustainably feeding the world's population under changing environmental, social and climate conditions. Hazard evaluation criteria include bioaccumulation/biodegradation and toxicity criteria relevant to both effects on fisheries stocks and seafood safety.	

2.2 Working Group 34: Review of applications for "Active Substances" to be used in ballast water management systems

Terms of Reference for WG 34

1 Consideration of development of necessary methodologies and information requirements in accordance with the "Procedure for approval of ballast water management systems that make use of Active Substances (G9)" (adopted by resolution MEPC 169(57)) by MEPC;

2 For Basic Approval, the Group should review the comprehensive proposal submitted by the Member of the Organization along with any additional data submitted as well as other relevant information available to the Group and report to the Organization;

In particular, the Group should undertake:

.1 scientific evaluation of the data set in the proposal for approval (see paragraphs 4.2, 6.1, 8.1.2.3, 8.1.2.4 of Procedure (G9));

.2 scientific evaluation of the assessment report contained in the proposal for approval (see paragraph 4.3.1 of Procedure (G9));

.3 scientific evaluation of the risks to the ship and personnel to include consideration of the storage, handling and application of the Active Substance (see paragraph 6.3 of Procedure (G9));

.4 scientific evaluation of any further information submitted (see paragraph 8.1.2.6 of Procedure (G9));

.5 scientific review of the risk characterization and analysis contained in the proposal for approval (see paragraph 5.3 of Procedure (G9));

.6 scientific recommendations on whether the proposal has demonstrated a potential for unreasonable risk to the environment, human health, property or resources (see paragraph 8.1.2.8 of Procedure (G9)); and

.7 preparation of a report addressing the above-mentioned aspects for consideration by MEPC (see paragraph 8.1.2.10 of Procedure (G9)).

3 For Final Approval, the Group should review the discharge testing (field) data and confirm that the residual toxicity of the discharge conforms to the evaluation undertaken for Basic Approval and that the previous evaluation of the risks to the ship and personnel including consideration of the storage, handling and application of the Active Substance remains valid. The evaluation will be reported to the MEPC (see paragraph 8.2 of Procedure (G9)); and

4 The Group should keep confidential all data, the disclosure of which would undermine protection of the commercial interests of the applicant, including intellectual property.

WG 34: REVIEW OF APPLICATIONS FOR "ACTIVE SUBSTANCES" TO BE USED IN BALLAST WATER MANAGEMENT SYSTEMS			
Agency Sponsors	**Existing/Potential Partners**	**Activities/Delivery**	**Communications**
IMO	MEPC	Establish testing and information requirements for approval applications for ballast water management (BWM) systems using active substances, in accordance with the BWM Convention Detailed evaluations of approval applications with regard to methodologies, risks to environmental and human health and ship safety Maintenance of a database on chemicals associated with the treatment of ballast water using active substances, including both active substances themselves and by-products of their use Development and maintenance of the MAMPEC model for the specific purpose of predicting the probable environmental concentration (PEC) of substances treated BW discharge in harbours (MAMPEC-BW)	Regular reporting to MEPC of evaluation results with recommendations regarding approval Open-access publication of evaluation methodology BW chemicals database is publicly available online via IMO's Global Integrated Shipping Information System (GISIS) MAMPEC-BW model is freely available in English, Chinese and Japanese. WG34 has published guidance on its use

Decade Outcome	**Contributions**
Clean Ocean	Evaluations include risks of accidental discharges of chemicals to water and atmosphere, as well as prediction and risk assessment of operational discharges of treated BW
Healthy/Resilient Ocean	Evaluations are integral to the BWM Convention, which is intended to control the spread of invasive marine species (IMS) in ships' ballast water. IMS are a significant threat to global marine biodiversity.
Productive Ocean	Evaluations include risks of bioaccumulation of harmful substances in seafood, and thus productivity and seafood marketability.
Predicted Ocean	
Safe Ocean	Evaluations include risks to ship safety as well as the health of both ships' crews and the general public.

Accessible Ocean	The BW chemicals database and MAMPEC-BW model are freely available not only to the public but also to local and national administrations for use in their own decisions regarding BWM. The active substances used for BW treatment are used in other water/wastewater treatment systems, so the chemical database has broader relevance to marine environmental management.
Inspiring/Engaging Ocean	
Decade Challenges	
Challenge 1: 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. Hazard evaluations of BMS using active substances are an established component of existing strategies to mitigate them, including hazards to biota and human health. The evaluations are relevant to understanding and mitigation of hazards from the use of these active substances in many other water/wastewater treatment systems.	
Challenge 9: Ensure comprehensive capacity development and equitable access to data, information, knowledge and technology across all aspects of ocean science and for all stakeholders. The BW chemicals database and and MAMPEC-BW model are freely available online; details instructions for MAMPEC-BW are provided. MAMPEC-BW is available in Japanese and Chinese versions as well as English.	

2.3 Working Group 38: Atmospheric input of chemicals to the oceans

WG38 does not currently have over-arching Terms of Reference for the overall work of the WG. Instead, because much of the work is conducted as a series of workshops, TORs are developed for each individual workshop

Terms of Reference for WG 38 Workshop on

The atmospheric input of chemicals to the ocean—management implications

1 Test the most appropriate approaches for scientists to engage with policymakers and managers in order to evaluate scientific evidence of environmental trends and their associated uncertainties related to the atmospheric input of certain chemicals to the ocean.

2 Use current information and/or modelling on the atmospheric deposition of the nutrients nitrogen and iron in the regions of the Southwest Indian Ocean as an example of an area where such deposition may be particularly important to biological productivity.

3 Have extensive involvement of students and early career scientists from the local region as part of a significant capacity-building effort.

4 Evaluate what type of additional scientific information might be necessary for managers and policymakers to feel comfortable about recommending specific actions in response to the identified trends.

5 Publish the outcomes of the workshop in a science- and policy-focused journal, as well as a document in the GESAMP Reports and Studies series, with recommendations for good practice in these areas of science and policy engagement.

Terms of Reference for Joint WG 38/WG 40 Workshop on

The atmospheric transport of microplastics to and from the ocean

1. Identify our current understanding and quantitative estimation of the major sources and types of atmospheric microplastics, their atmospheric transport paths, and their inputs to and emissions from the global ocean; and

2. Develop guidelines on appropriate future atmospheric and marine sampling and measurement methods and strategies, to enable more accurate estimations of the above to be made.

WG 38: ATMOSPHERIC INPUT OF CHEMICALS TO THE OCEANS			
Agency Sponsors	**Existing/Potential Partners**	**Activities/Delivery**	**Communications**
WMO IMO IAEA IOC	GESAMP WG 40 SCOR US National Science Foundation SCOR SOLAS University of East Anglia	Workshop on ocean management and policy implications of air/sea chemical exchange in Southwest Indian Ocean in 2022 Workshop (joint with WG 40) on atmospheric transport of microplastics to and from the ocean was held in November 2020	Peer-reviewed journal publications from previous work GESAMP report on these publications Workshop reports

Decade Outcome	**Contributions**
Clean Ocean	Continuing work on ocean/atmosphere exchange and transport of pollutants. Workshop report on microplastics atmospheric transport will synthesise existing measurements and flux calculations. Workshop report on microplastics atmospheric transport will identify key knowledge gaps. Workshop report on microplastics atmospheric transport will present a draft global air/sea research strategy for microplastics.
Healthy/Resilient Ocean	Improved knowledge of air-sea exchange and atmospheric transport will improve our understanding of ocean ecosystems, in particular land-sea interactions. Continuing contributions to understanding of the global nitrogen and iron cycles. WG38 activities include addressing climate change impacts on ocean acidification and nitrogen and iron transport. TORs explicitly address engagement with policymakers and managers, and their information needs.
Productive Ocean	Work on atmospheric inputs of nutrients in the SW Indian Ocean includes a specific focus on ocean productivity.
Predicted Ocean	Work is based on atmospheric models previously used by WG38 which estimate current and predict future inputs of a range of chemicals via atmospheric transport.
Safe Ocean	
Accessible Ocean	Extensive involvement of students and early-career scientists from the SW Indian Ocean region will build capacity to generate knowledge and communicate it to policymakers and managers. Evaluation of information needs for policy makers and managers will build regional capacity to disseminate scientific knowledge in the specific regional context.

Inspiring/Engaging Ocean	

Decade Challenges

Challenge 1: 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.

WG38 modelling provides a global geographic distribution of the atmospheric input of a range of contaminants to the global ocean. It allows for projecting future inputs under various development scenarios. This work will be tested at a regional scale in the SW Indian Ocean in relation to the effects of atmospheric nutrient inputs on biological productivity.

Joint work with WG 40 will increase knowledge on the relative role of atmospheric transport of microplastics to the ocean, including geographic distribution. The WG is developing a draft global research strategy.

Challenge 8: Through multi-stakeholder collaboration, develop a comprehensive digital representation of the ocean, including a dynamic ocean map, which provides free and open access for exploring, discovering, and visualizing past, current, and future ocean conditions in a manner relevant to diverse stakeholders.

WG 38's modelling work provides digital global mapping of estimated current and future atmospheric inputs of a range of substances, from both anthropogenic and natural sources.

Challenge 9: Ensure comprehensive capacity development and equitable access to data, information, knowledge and technology across all aspects of ocean science and for all stakeholders.

The SW Indian Ocean work has a strong focus on involving students and early-career scientists from the region explicitly for capacity building. Outputs will include recommendations for good practice in policy engagement.

2.4 Working Group 40: Sources, fate and effects of plastics and micro-plastics in the marine environment

Terms of reference for fourth phase of WG 40

(Terms of reference 1 to 5 to include social, environmental and economic aspects)

1 Review and further develop risk assessment methods for marine litter and microplastics & identify data needs – based on the outcome of the 2019 GESAMP risk workshop

2 Assess the effects of marine litter and macro-plastics – e.g. human wellbeing, biodiversity & animal welfare, food security, direct & indirect cost to different sector, risk perception & communication. This will include consideration of Covid-19 related litter, especially material used for medical and hygiene purposes.

3 Assess the effects of nano- & micro-plastics – e.g. chemical contaminants, biodiversity, human health, risk perception & communication

4 Assess the effects of transfer of biota by marine litter and microplastics – e.g. human welfare, biodiversity, direct & indirect costs, pathogens, risk perception & communication

5 Carry out initial risk assessment (based on terms of reference 1 to 4)

WG 40: SOURCES, FATE AND EFFECTS OF PLASTICS AND MICRO-PLASTICS IN THE MARINE ENVIRONMENT			
Agency Sponsors	**Existing/Potential Partners**	**Activities/Delivery**	**Communications**
IOC-UNESCO UNEP	GESAMP WG 38	Workshop (joint with WG 38) on atmospheric transport of microplastics to and from the ocean	Workshop reports GESAMP report

Decade Outcome	**Contributions**
Clean Ocean	Workshop report on microplastics atmospheric transport will synthesise existing measurements and flux calculations. Workshop report on microplastics atmospheric transport will identify key knowledge gaps. Workshop report on microplastics atmospheric transport will present a draft global air/sea research strategy for microplastics. Identification of data needs for risk assessment is a critical first step in prioritising and then filling knowledge gaps. Previous WG work has addressed sources and fates as well as effects, including knowledge gaps. Planned work will further enhance knowledge of effects, including knowledge gaps relevant to risk assessment and management.
Healthy/Resilient Ocean	
Productive Ocean	Risk assessment will include risks to food security and various socio-economic sectors. This includes direct and indirect costs.
Predicted Ocean	Workshop on atmospheric transport of microplastics addresses interactions with land and the atmosphere. It will be a first step towards prediction.
Safe Ocean	Risk assessment will address risks to human health, including from contaminants and pathogens.
Accessible Ocean	The work includes an emphasis on risk perception and communication, which is essential to communicating knowledge to the public and to support decision-making by policy makers and managers. WG WG has included early-career scientists from developing countries. Some WG some meetings have been in developing countries and included further engagement with early-career scientists from the regions concerned.
Inspiring/Engaging Ocean	

Decade Challenges

Challenge 1: 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. Further development of risk assessment methods for plastics in the ocean will support the development of mitigation solutions. Increased knowledge of the effects of plastics across the range of marine environmental values and services is critical to rigorous risk assessment. Joint work with WG 38 will increase knowledge on the relative role of atmospheric transport of microplastics to the ocean, including geographic distribution. The WG is developing a draft global research strategy for this topic.
Challenge 10: Ensure that the multiple values and services of the ocean for human wellbeing, culture, and sustainable development are widely understood, and identify and overcome barriers to behaviour change required for a step change in humanity's relationship with the ocean. All aspects of the work will include social and economic aspects in addition to environmental ones.

2.5 Working Group 41: Ocean interventions for climate change mitigation

Terms of reference for second phase of WG 41

1 The overall aims of GESAMP Working Group 41 for the second phase are:

.1 to better understand the potential environmental and societal impacts of different ocean interventions for climate change on the ocean;

.2 to develop a framework to integrate inputs from natural sciences and societal disciplines into a holistic assessment of ocean interventions for climate change mitigation or other purposes; and

.3 to provide advice to the London Protocol Parties to assist them in identifying those ocean interventions for climate change mitigation, or other purposes, consistent with the London Protocol's definition of marine geoengineering, that it might be prudent to consider for listing in the new Annex 4 of the Protocol.

2 The second phase of the GESAMP Working Group 41 study should:

.1 Develop a flow chart and questionnaire with associated guidance to elicit information from proposers of ocean interventions for climate change mitigation or other purposes consistent with the London Protocol's definition of marine geoengineering, to enable a preliminary assessment (including constructive feedback) of their techniques by regulators, policy makers, funders or anyone considering or permitting proposals. The flow chart and questionnaire with associated guidance will be aimed to facilitate the London Protocol 'Guidance for consideration of marine geoengineering activities' (IMO, 2015). The Working Group should also consider additional incentives that can be provided to proposers of ocean interventions for climate change mitigation to comprehensively report their approaches in the permanent public record, drawing upon the discussions of these incentives in the Working Group report. Examples of such incentives to proposers of ocean interventions for climate change mitigation include modelling assessments (externally funded) that straddle conceptual, box models on to more complex approaches such as CDRMIP (Carbon Dioxide Removal Model Inter-comparison Project).

.2 Develop a framework to integrate inputs from natural sciences and societal disciplines into a holistic assessment of ocean interventions for climate change mitigation or other purposes consistent with the London Protocol's definition of marine geoengineering, to be used by regulators, policy-makers, funders or anyone considering or permitting proposals, exploring the use of a systems approach framework such as that presented at the March 2019 workshop (see Elliott et al., 2015; Cormier and Elliott, 2019; Barnard and Elliott, 2015).

.3 Provide advice to the London Protocol Parties:

a) identifying promising ocean interventions for climate change mitigation or other purposes i.e. those consistent with the London Protocol's definition of marine geoengineering, that might be worthwhile to consider for listing in the new annex 4 of the Protocol, including techniques having the potential to move to field testing;

b) developing an outline of the specific issues to be addressed in an assessment framework for each of a subset of techniques identified 11.3(a) above, using the London Protocol Assessment Framework for Scientific Research Involving Ocean Fertilization as a template;

c) providing an initial assessment of monitoring and verification approaches, including the difficulties and challenges, for each of the techniques, meriting detailed scrutiny, identified under 9.3(a) above; and

d) identifying significant gaps in knowledge and uncertainties associated with each of the small suite of techniques identified under 2.3(a) above that need to be addressed to assess their implications for the marine environment and, where appropriate, the atmosphere.

.4 Provide brief updates, based on new scientific evidence since the WG 41 report was published in March 2019 (in particular from the IPCC 'Special Report on the Ocean and Cryosphere in a Changing Climate' published in 2019, and the forthcoming IPCC 6th Assessment Reports) on:

a) any new proposed ocean interventions that may have potential for climate change mitigation or other purposes consistent with the London Protocol's definition of marine geoengineering such as fisheries enhancement, and their scientific practicality and efficacy; and

b) the potential environmental and societal impacts of ocean interventions for climate change mitigation or other purposes consistent with the London Protocol's definition of marine geoengineering, on the marine environment and, where appropriate, the atmosphere.

.5 Produce reports and potentially peer-reviewed scientific papers on the points above at appropriate points in the work plan.

WG 41: OCEAN INTERVENTIONS FOR CLIMATE CHANGE MITIGATION			
Agency Sponsors	**Existing/Potential Partners**	**Activities/Delivery**	**Communications**
IMO IOC-UNESCO WMO	ClimateWorks SOLAS CDRMIP IMBeR IPCC UNFCCC	WG meetings	Framework for integrating natural and social sciences for holistic assessments of proposed interventions GESAMP Reports Potentially, peer-reviewed publications

Decade Outcome	**Contributions**
Clean Ocean	Primary purpose of the WG is to support assessment of possible interventions on the whole ocean ecosystem, as well as specific regions/ecosystems. Integration of natural and social scientific considerations is essential for ecosystem-based management and sustainable development..
Healthy/Resilient Ocean	
Productive Ocean	Identification of information needs for holistic assessment of potential interventions, with a framework and guidance for collecting and interpreting that information, is critical to prediction, interpretation and communication of potential impacts.
Predicted Ocean	
Safe Ocean	
Accessible Ocean	Direct linkage of the WGs outputs to international bodies and processes inherently provides open and equitable access to information, and provides for quality control and dissemination of knowledge about potential intervention effects to all stakeholders.
Inspiring/Engaging Ocean	

Decade Challenges
Challenge 2: Understand the effects of multiple stressors on ocean ecosystems, and develop solutions to monitor, protect, manage and restore ecosystems and their biodiversity under changing environmental, social and climate conditions.

Assessment of the effects of potential climate mitigation interventions on the ocean inherently requires and understanding of the interaction of multiple stressors with climate, society and the environment.
Challenge 4: Generate knowledge, support innovation, and develop solutions for equitable and sustainable development of the ocean economy under changing environmental, social and climate conditions. The WG will identify knowledge gaps and research priorities to develop In developing an assessment framework for climate interventions, as well as monitoring and verification approaches. The framework will be a holistic one that integrates natural and social scientific inputs. The WG will develop a methodology (flow chart, questionnaire, and associated guidance) to elicit information for preliminary assessment of proposals for ocean interventions to mitigate climate change by regulators, policy makers, funders, and other stakeholders.
Challenge 5: Enhance understanding of the ocean-climate nexus and generate knowledge and solutions to mitigate, adapt and build resilience to the effects of climate change across all geographies and at all scales, and to improve services including predictions for the ocean, climate and weather. The entire TORs for WG 41 directly address this challenge
Challenge 9: Ensure comprehensive capacity development and equitable access to data, information, knowledge and technology across all aspects of ocean science and for all stakeholders. The assessment framework is specifically intended to be used by regulators, policymakers, funders or anyone considering or permitting intervention proposals.
Challenge 10: Ensure that the multiple values and services of the ocean for human wellbeing, culture, and sustainable development are widely understood, and identify and overcome barriers to behaviour change required for a step change in humanity's relationship with the ocean. All aspects of the work will include social and economic aspects in addition to environmental ones.

2.6 Working Group 42: Impacts of wastes and other matter in the marine environment from mining operations, including marine mineral mining

Terms of reference for WG 42

The working group on the impacts on tailings from mining operations on the marine environment is requested to undertake a literature review on the following aspects:

1 Identify and provide a better understanding of potential environmental impacts of marine disposal of tailings and associated wastes from land-based mining operations (hereinafter referred to as "mine tailings"), taking into account potential linkages between deep water ecosystems at the disposal site and other (e.g., ecological, biological) resources in the water column. The impacts could include, but are not limited to, those identified in the report of the workshop on mine tailings provided to GESAMP at its last meeting (GESAMP 42/7/1);

2 Review the extent and suitability of baseline assessments (prior to any construction or discharge) conducted to date and identify the key elements for comprehensive surveys of baseline conditions from which abiotic and biotic impacts can be assessed, taking into account the latest detection technologies of marine pollution and its impact to the organisms;

3 Review and identify the best practices in modeling the physical and chemical behavior of discharged mine tailings (e.g. slurries), including the shearing and upwelling of both the solids and soluble fractions, as well as the significance of tidal dispersion and potential for long-range transport of fine materials, and determine whether existing models are adequate or further development is needed;

4 Review and evaluate the processes of exposure and effect and the pathways for mine tailings disposal operations, including those related to the physical presence of the wastes, exposure to associated contaminants, their accumulation, and the potential effects at community level;

5 Implications arising from the fact that marine organisms normally used for toxicity testing are from upper layers of marine water, not the deep sea;

6 Review and identify physical and ecological models to estimate the recovery processes of deep-sea ecosystems around the possible impacted area; and

7 Produce a report on the above work under a time frame and any other reporting requirements to be agreed between LC/LP and the GESAMP.

WG 42: IMPACTS OF WASTES AND OTHER MATTER IN THE MARINE ENVIRONMENT FROM MINING OPERATIONS, INCLUDING MARINE MINERAL MINING			
Agency Sponsors	**Existing/Potential Partners**	**Activities/Delivery**	**Communications**
IMO UNEP ISA	One Ocean Hub	In-person and virtual meetings, correspondence Draft report on first TOR completed November 2020	

Decade Outcome	**Contributions**
Clean Ocean	The WG will provide a better understanding of the impacts of mining wastes. Understanding of exposure and effects pathways for mining wastes and associated contaminants will be strengthened. The suitability of current practices in assessing contaminant toxicity will be evaluated. Knowledge gaps and opportunities to improve practice may be identified.
Healthy/Resilient Ocean	Better knowledge of and tools to predict the recovery of ecosystems, particularly poorly-understood deep-sea ones, will help develop management systems to maintain their resilience. Improved understanding of linkages between deep ecosystems and the water column will support management for resilience.
Productive Ocean	
Predicted Ocean	Review and identification of good practice for baseline assessments and physical/chemical modelling of contaminant transport/fate after release, will improve impact predictions. Understanding of ecosystem recovery processes and time scales is needed for impact prediction.
Safe Ocean	
Accessible Ocean	
Inspiring/Engaging Ocean	

Decade Challenges
Challenge 1: 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.

Major foci of the WG are the effects and potential distributions of contaminants released by land- and sea-based mineral mining. Recommendations for good practice in baseline assessments, and modelling the physical and chemical behaviour of mining wastes after discharge, is critical to the prediction and mitigation of adverse effects.
Challenge 4: Generate knowledge, support innovation, and develop solutions for equitable and sustainable development of the ocean economy under changing environmental, social and climate conditions. Mining is important to the global economy; improved impact prediction and management will increase its environmental and social sustainability.

2.7 Working Group 43: Sea-based Sources of marine litter

Terms of Reference for WG 43

1 The GESAMP Working Group on Sea-based Sources of Marine Litter is an expert group to provide best available scientific assessment on the sources, relative contributions, and range and extent of impacts of sea-based sources of marine litter, particularly from the shipping and fishing sectors :

.1 Identify sources of marine litter from sea-based sources, including but not limited to fishing, aquaculture, shipping, dumping of waste and other matter, and other ocean activities;

.2 Estimate the relative contribution and impacts of different sea-based sources of marine litter;

.3 Assess characteristics and quantities of plastic generated by fishing and shipping;

.4 Identify areas of documented input and accumulation of abandoned, lost and discarded fishing gear;

.5 . Quantify environmental, social and economic impacts of abandoned, lost and otherwise discarded fishing gear; and

.6 Review and compare options for solution delivery to the challenge of abandoned, lost and otherwise discarded fishing gear.

WG 43: SEA-BASED SOURCES OF MARINE LITTER			
Agency Sponsors	**Existing/Potential Partners**	**Activities/Delivery**	**Communications**
IMO, FAO, UNEP	IMO Marine Environment Protection Committee (MEPC) FAO Committee on Fisheries (COFI) UNEP Global Partnership on Marine Litter	Regular meetings to collate and compile scientific evidence and datasets on sea-based sources of marine litter Identification of global knowledge gaps	Interim reports to sponsoring agencies MEPC and COFI GESAMP Reports

Decade Outcome	**Contributions**
Clean Ocean	WG identifies options to reduce plastic waste inputs to the global ocean from sea-based industries, especially the fisheries and shipping sectors.
Healthy/Resilient Ocean	Identification of impacts on marine life and habitats provides and evidence-based rationale for sea-based source reduction and mitigation.
Productive Ocean	Identification of options to reduce plastic input to the ocean includes measures to reducing the quantity and impact of abandoned, lost, or discarded fishing gear, which impacts the productivity of target and non-target resources. Information on plastic inputs from aquaculture supports development of waste-reduction measures to support sustainable marine food production.
Predicted Ocean	
Safe Ocean	Development of mitigation strategies to reduce marine debris reduces navigation hazards and threats to human health.
Accessible Ocean	
Inspiring/Engaging Ocean	

Decade Challenges
Challenge 1: 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. Work includes global assessment of sources, geographic distribution, and fates of marine litter, informing mitigation measures.

Challenge 3: Generate knowledge, support innovation, and develop solutions to optimise the role of the ocean in sustainably feeding the world's population under changing environmental, social and climate conditions. Understanding of sea-based marine litter elucidates the economic impacts on fishers and farmers in terms of lost opportunity, productivity, and revenue.
Challenge 4: Generate knowledge, support innovation, and develop solutions for equitable and sustainable development of the ocean economy under changing environmental, social and climate conditions. Mitigation measures for sea-based sources of marine litter create novel opportunities for income generation by ocean users (e.g. management of end-of-life fishing gear and recycling of solid waste from ships).

2.8 Working Group 44: Biofouling management

Terms of Reference for WG 44

2 Comprehensive identification and description of both primary and secondary pathways for the transfer of non-indigenous species (NIS), including, but not limited to:

.7 fishing (e.g. ships, gear, lines);

.8 aquaculture (e.g. structures, cages, buoys, netting);

.9 shipping (e.g. hulls, niche areas, propellers, ropes, anchors);

.10 other shipping (e.g. recreational boating, recreational fishing, Aids to Navigation);

.11 marine offshore operations (e.g. offshore platforms and structures);

.12 ocean renewable energy generation (e.g. underwater turbines, shafts);

.13 ocean monitoring (e.g. measuring instruments); and

.14 coastal industry infrastructure (e.g. ports, marinas, cooling towers, water purifying units).

3 Description and assessment of impacts on biodiversity (alteration of biodiversity) of the introduction and/or spread of NIS via the identified pathways.

4 Description and assessment of impact of and costs resulting from the introduction and/or spread of NIS via the identified pathways (economic loss and/or alteration of assets; management costs including cost of preventative and reactive measures/mitigation strategies) on human health, social activities and the economy (such as fisheries, aquaculture, fish processing, tourism and related activities and businesses).

5 Provision of an analysis of best management approaches within impacted industries, including the use of emerging technologies, techniques and methods to prevent or reduce the introduction and/or spread of NIS and water contamination resulting from cleaning activities.

6 Provision of recommendations to reduce or prevent the introduction or spread of NIS.

7 Identification of data gaps, in relation to ToR 1 to 4 above, and prioritization for further work:

.1 consider additional work that may be useful to be carried out by the Working Group beyond what is listed above;

.2 peer review of the draft report required; and

.3 provisions for publication, dissemination and outreach.

WG 44: BIOFOULING MANAGEMENT			
Agency Sponsors	**Existing/Potential Partners**	**Activities/Delivery**	**Communications**
IOC-UNESCO IMO UNDP	GloFouling partnerships	Virtual meetings, monthly chats to address progress of work and questions arising	GESAMP Report in Progress

Decade Outcome	**Contributions**
Clean Ocean	Study will address avoidance of introduction and spread of non-indigenous, potentially invasive species by biofouling considering various maritime activities, avoidance of excessive use of biocides for biofouling management, environmentally sustainable antifouling strategies, methods, and technology, and management of wastes from biofouling management (e.g., vessel cleaning).
Healthy/Resilient Ocean	Sustainable biofouling management helps avoid the introduction of non-indigenous invasive marine species (IMS), a major threat to marine biodiversity and ecosystem integrity. The WG will consider species introductions via biofouling in the context of climate change (e.g., altered temperature regimes in relation to the thermal tolerances of invasive species.
Productive Ocean	Invasive marine species have significantly impacted wild fisheries productivity in some areas, and could further reduce productivity in future. Knowledge of good practice in biofouling management in, and implementing a holistic approach to, the aquaculture sector potentially contributes to productivity (by avoiding negative effects of biocides on cultured organisms) and seafood safety (by avoiding contamination of aquaculture products. Sustainable biofouling management supports the energy efficiency of shipping as well as coastal infrastructure (e.g., power and desalination plants, ports). The WG will assess impacts of IMS translocated by biofouling in terms of economic costs.
Predicted Ocean	
Safe Ocean	Some IMS translocated in biofouling are human pathogens. Effective biofouling management contributes to safe navigation.
Accessible Ocean	
Inspiring/Engaging Ocean	

Decade Challenges
Challenge 1: 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. Strategies for minimisation of biocide use and sustainable biofouling management will remove or mitigate adverse effects of biofouling management.
Challenge 2: *Understand effects of multiple stressors and develop solutions to monitor, protect, manage and restore ecosystems and their biodiversity under changing environmental, social and climate conditions.* Sustainable biofouling management has to consider the interations of multiple stressors, including species introductions, pathogens, biocides, microplastics, and biocide, energy use, and noise emissions.
Challenge 3: Generate knowledge, support innovation, and develop solutions to optimise the role of the ocean in sustainably feeding the world's population under changing environmental, social and climate conditions. Sustainable biofouling management in the aquaculture industry contributes to sustainable seafood production.
Challenge 4: Generate knowledge, support innovation, and develop solutions for equitable and sustainable development of the ocean economy under changing environmental, social and climate conditions. Biofouling management is needed in shipping and a range of ocean industries, for example to maintain energy and operational efficiency and structural integrity of marine and coastal infrastructure. Improving the sustainability of biofouling management supports the sustainability of these industries.

2.9 Working Group 45: Climate change and greenhouse gas related impacts on contaminants in the ocean

Terms of Reference for WG 45

1 Critically review existing research on:

.1 The effect of changes in ocean physics and chemistry on the speciation, cycling, fate and bioavailability of diverse contaminants including trace elements, radionuclides, organic pollutants and nutrients.

.2 The effect of such changes on important coastal and marine resources.

2 Identify knowledge gaps.

3 Make recommendations for future research directions on the effect of changes in ocean physics and chemistry on the speciation, cycling and bioavailability of diverse contaminants including trace elements, radionuclides, organic pollutants and nutrients.

4 Develop a plan for publication and dissemination of the findings of the WG.

5 Propose additional work relevant to the topic of the WG that may be useful to the sponsoring agencies and which could be carried out by the WG beyond what is listed above.

WG 45: CLIMATE CHANGE AND GREENHOUSE GAS RELATED IMPACTS ON CONTAMINANTS IN THE OCEAN			
Agency Sponsors	**Existing/Potential Partners**	**Activities/Delivery**	**Communications**
IAEA IOC-UNESCO IMP UNEP WMO	SCOR (several SCOR Working Groups) IOC-UNESCO Group of Experts on Multiple Ocean Stressors GPNM IOC-UNESCO N-CIRP	In-person and virtual meetings 2021-2023 First draft report April 2022 Final report end 2023	

Decade Outcome	**Contributions**
Clean Ocean	The transport, fate and distribution – and therefore effects – of a range of contaminants including trace elements, radionuclides, organic pollutants and nutrients is largely determined by regional and global physical and biogeochemical process profoundly affected by climate change. Identifying and filling knowledge gaps about these climate change impacts is essential to policy development.
Healthy/Resilient Ocean	Climate change effects on thermocline depth, ocean circulation and pH, oxygenation, sea level, ice cover, and the frequency and intensity of extreme climatic events are not only multiple stressors in and of themselves. They also generate changes in contaminant transport, fate, distribution, chemical speciation, and potentially biological effects on organisms that also represent multiple stressors. The specific aim of the WG is to address multi-stressor effects.
Productive Ocean	
Predicted Ocean	The remit of the WG specifically includes the review of relevant current modelling and identification of knowledge gaps and research priorities.
Safe Ocean	
Accessible Ocean	
Inspiring/Engaging Ocean	

Decade Challenges (list as relevant for each WG, following is just random examples)

Challenge 2: Understand the effects of multiple stressors on ocean ecosystems, and develop solutions to monitor, protect, manage and restore ecosystems and their biodiversity under changing environmental, social and climate conditions.

WG will review, and recommend future research on, the effects of multiple climate-change-related changes in the ocean/atmosphere system on multiple contaminants.
Challenge 3: Generate knowledge, support innovation, and develop solutions to optimise the role of the ocean in sustainably feeding the world's population under changing environmental, social and climate conditions. WG will review, and recommend future research on, the effects of such changes on important coastal and marine resources, including fisheries resources.

3 Ocean Decade Outcomes and Challenges (Extracted from Implementation Plan v. 2)

3.1 Ocean Decade Targeted Outcomes

The following seven outcomes describe the 'ocean we want' at the end of the Decade. They describe both the desired state of the ocean (Outcomes 1 and 2), and the desired state of society's use of, and interaction with, the ocean (Outcomes 3 to 7).

Outcome 1: A clean ocean where sources of pollution are identified and reduced or removed. Society generates a vast range of pollutants and contaminants including marine debris, plastic, excess nutrients, anthropogenic underwater noise, hazardous chemicals, organic toxins, and heavy metals. These pollutants and contaminants derive from a wide variety of land and sea based sources, including point and non-point sources. The resulting pollution is unsustainable for the ocean and jeopardises ecosystems, human health, and livelihoods. It will be critical to fill urgent knowledge gaps and generate priority interdisciplinary and co-produced knowledge on the causes and sources of pollution and its effects on ecosystems and human health. This knowledge will underpin solutions co-designed by multiple stakeholders to eliminate pollution at the source, mitigate harmful activities, remove pollutants from the ocean, and support the transition of society into a circular economy.

Outcome 2: A healthy and resilient ocean where marine ecosystems are understood, protected, restored and managed. Degradation of marine ecosystems is accelerating due to unsustainable activities on land and in the ocean. To sustainably manage, protect or restore marine and coastal ecosystems, priority knowledge gaps of ecosystems, and their reactions to multiple stressors, need to be filled. This is particularly true where multiple human stressors interact with climate change, including acidification and temperature increase. Such knowledge is important to develop tools to implement management frameworks that build resilience, recognise thresholds and avoid ecological tipping points, and thus ensure ecosystem functioning and continued delivery of ecosystem services for the health and wellbeing of society and the planet as a whole.

Outcome 3: A productive ocean supporting sustainable food supply and a sustainable ocean economy. The ocean is the foundation for future global economic development and human health and wellbeing, including food security and secure livelihoods for hundreds of millions of the world's poorest people. Knowledge and tools to support the recovery of wild fish stocks, deploy sustainable fisheries management practices, and support the sustainable expansion of aquaculture, while protecting essential biodiversity and ecosystems, will be essential. The ocean also provides essential; goods and services to a wide range of established and emerging industries including extractive industries, energy, tourism, transport and pharmaceutical industries. Each of these sectors has specific, priority needs in terms of increased knowledge, and support to innovation, technological development and decision support tools to minimise risk, avoid lasting harm, and optimise their contribution to the development of a sustainable ocean economy. Governments also require information and tools, for example via national accounts that incorporate ocean indicators, to guide development of sustainable ocean economies and promote marine sectors.

Outcome 4: A predicted ocean where society understands and can respond to changing ocean conditions. The vast volume of the ocean is neither adequately mapped nor observed, nor is it fully understood. Exploration and understanding of key elements of the changing ocean including its physical, chemical and biological components and interactions with the atmosphere and cryosphere are essential, particularly under a changing climate. Such knowledge is required from the land-sea interface along the world's coasts to the open ocean and from the surface to the deep ocean seabed. It needs to include past, current and future ocean conditions. More relevant and integrated understanding and accurate prediction of ocean ecosystems and their responses and interactions will underpin the implementation of ocean management that is dynamic and adaptive to a changing environment and changing uses of the ocean.

Outcome 5: A safe ocean where life and livelihoods are protected from ocean-related hazards. Hydro-meteorological, geophysical, biological and human induced hazards create devastating, cascading and unsustainable impacts for coastal communities, ocean users, ecosystems, and economies. The changing frequency and/or intensity of weather- and climate- related hazards is exacerbating these risks. Mechanisms and processes for assessing priority risks, mitigating, forecasting and warning of these hazards and formulating adaptive responses are required to reduce short- and longer-term risks on land and at sea. Higher density ocean data and improved forecast systems - including those related to sea level, marine weather and climate are needed from near real time through decadal scales. When these enhancements are linked to education, outreach, and communication, they will empower policy and decision-making, and they will mainstream individual and community resilience.

Outcome 6: An accessible ocean with open and equitable access to data, information and technology and innovation. Inequalities in ocean science capacity and capabilities need to be eradicated through simultaneously improving access to and quality control of data, knowledge, and technology. This needs to be coupled with increased skills and opportunities to engage in data collection, knowledge generation and technological development, particularly in LDCs, SIDS and LLDCs. Increased dissemination of quality controlled and relevant ocean knowledge to the scientific community, governments, educators, business and industry, and the public through relevant and accessible products will improve management, innovation and decision-making contributing to societal goals of sustainable development.

Outcome 7: An inspiring and engaging ocean where society understands and values the ocean in relation to human wellbeing and sustainable development. In order to incite behaviour change and ensure the effectiveness of solutions developed under the Decade there needs to be a step change in society's relationship with the ocean. This can be achieved through ocean literacy approaches, formal and informal educational and awareness raising tools, and through measures to ensure equitable physical access to the ocean. Together these approaches will build a significantly broader understanding of the economic, social, and cultural values of the ocean by society and the plurality of roles that it plays to underpin health, wellbeing and sustainable development. This outcome will highlight the ocean as a place of wonder and inspiration, thus also influencing the next generation of scientists, policy makers, government officials, managers and innovators.

3.2 Ocean Decade Challenges

The Ocean Decade Challenges represent the highest level of the Decade Action Framework. They articulate the most immediate priorities for the Decade. They aim to unite Decade partners in collective action, thus ensuring that the whole of the Decade is greater than the sum of its parts, and shaping the overall contribution of the Decade to the 2030 Agenda and other policy frameworks.

Throughout the Decade, communities of practice comprising diverse stakeholders will be convened around the Ocean Decade Challenges via the stakeholder engagement mechanisms described in Section 2.6 of the implementation plan. A wide range of stakeholders will translate the Challenges into relevant Decade Actions at the global, regional, national and local scales. The priority, form and scope of related Decade Actions will be different across the globe depending on the prevailing context. For example, they may align with priorities contained in national ocean policies or focus efforts in areas of particular significance such as marine World Heritage Sites or underwater cultural heritage sites.

The Challenges have been distilled from discussions with stakeholders throughout the preparation phase of the Decade including the regional consultation workshops. They include 'Knowledge and Solutions Challenges' that focus on scientific research priorities and which encompass social, economic and political science disciplines as well as indigenous and local knowledge; 'Essential Infrastructure Challenges' that focus on the infrastructure needed to underpin the ambitions of the Decade; and 'Foundational Challenges' that focus on essential, cross-cutting elements of the enabling environment for the Decade.

The Challenges may evolve and change as issues are resolved over the course of the Decade. New Challenges may be added as issues emerge. Stakeholders will be involved in the process of revising and updating the Challenges via the engagement and review mechanisms outlined in Sections 2.6 and 3.3 of the implementation plan.

The present set of ten Ocean Decade Challenges is as follows:

Knowledge and Solutions Challenges

Challenge 1: 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.

Challenge 2: Understand the effects of multiple stressors on ocean ecosystems, and develop solutions to monitor, protect, manage and restore ecosystems and their biodiversity under changing environmental, social and climate conditions.

Challenge 3: Generate knowledge, support innovation, and develop solutions to optimise the role of the ocean in sustainably feeding the world's population under changing environmental, social and climate conditions.

Challenge 4: Generate knowledge, support innovation, and develop solutions for equitable and sustainable development of the ocean economy under changing environmental, social and climate conditions.

Challenge 5: Enhance understanding of the ocean-climate nexus and generate knowledge and solutions to mitigate, adapt and build resilience to the effects of climate change across all geographies and at all scales, and to improve services including predictions for the ocean, climate and weather.

Essential Infrastructure Challenges

Challenge 6: Enhance multi-hazard early warning services for all geophysical, ecological, biological, weather, climate and anthropogenic related ocean and coastal hazards, and mainstream community preparedness and resilience.

Challenge 7: Ensure a sustainable ocean observing system across all ocean basins that delivers accessible, timely, and actionable data and information to all users.

Challenge 8: Through multi-stakeholder collaboration, develop a comprehensive digital representation of the ocean, including a dynamic ocean map, which provides free and open access for exploring, discovering, and visualizing past, current, and future ocean conditions in a manner relevant to diverse stakeholders.

Foundational Challenges

Challenge 9: Ensure comprehensive capacity development and equitable access to data, information, knowledge and technology across all aspects of ocean science and for all stakeholders.

Challenge 10: Ensure that the multiple values and services of the ocean for human wellbeing, culture, and sustainable development are widely understood, and identify and overcome barriers to behaviour change required for a step change in humanity's relationship with the ocean.