- Scoping Paper, June 2021-

Augmented Observing and Forecasting Capacity for Marine Life

In collaboration with the GOOS Biology and Ecosystems Expert Panel, the Marine Biodiversity Observation Network (MBON / GEO BON), key UN Ocean Decade programmes and other relevant international, regional, and national stakeholders, this activity should identify the priority actions requiring G7 support to advance the development of a global observing and forecasting system for marine life by 2030, including augmenting and standardising species and ecosystem observations; enhancing data assimilation, modelling and forecasting capacity; increasing observations and baseline data through biodiversity data mobilization actions across the G7; and promoting the adoption and use of observing and information management standards for marine biodiversity data.

Action Areas 1, 3, and 4

1. BACKGROUND INFORMATION

A vibrant and sustainable blue economy rests on a foundation of scientific knowledge, notably knowledge of marine life. Yet biodiversity is poorly integrated into the ocean observing networks. The current Global Ocean Observing System largely focuses on physical and biogeochemical observations, while significant areas of the blue economy require metrics on species and ecosystem services, as concluded and recommended by the OECD[1].

In 2019, the G7 FSOI Working Group agreed that augmenting observatories with biological and ecosystem variables was a key area in which the G7 could add value. The Working Group suggested that the Coordination Centre should create strong links with the GOOS Biology and Ecosystems Panel to further develop this activity.

In early 2021, the Coordination Centre initiated discussions with the GOOS Bio/Eco Panel, the Marine Biodiversity Observation Network (MBON / GEO BON), leaders of international biology and ecosystem data management programmes and international modelling / forecasting projects, and lead authors of key UN Decade programmes to identify areas where the G7 may add value. Joining GOOS and MBON, the following groups participated in scoping this G7 FSOI activity document (programme descriptions and their relevance to this G7 FSOI activity are provided in the Annex at the end of this document):

- Marine Life 2030 (ML2030): A Global Integrated Marine Biodiversity Information Management and Forecasting System for Sustainable Development and Conservation
- The Ocean Biomolecular Observing Network (OBON) Programme
- Deep Ocean Observing Strategy (DOOS) Decade Science Plan
- Deep Ocean Stewardship Initiative Challenger 150
- The Ocean Biodiversity Information System (OBIS)
- The OceanPredict ForeSea Decade Programme, the Synergistic Ocean Observing Network for Impactful and Relevant Ocean Prediction (SynObs) Decade project, developed and

[1] OECD (2016), *The Ocean Economy in 2030*, OECD Publishing, Paris, https://doi.org/10.1787/9789264251724-en. OECD. 2019. Rethinking Innovation for a Sustainable Ocean Economy, OECD Publishing, Paris, https://doi.org/10.1787/9789264311053-en.

supported by the OceanPredict Observing System Evaluation Task Team (OS-Eval TT) and ForeSea, and the OceanPredict Marine Ecosystem Analysis and Prediction Task Team (MEAP-TT), in collaboration with the Coastal Ocean and Shelf Seas Task Team (COSS-TT)
- The CoastPredict Programme, a GOOS co-sponsored Decade Programme

Based on these initial consultations, the proposed G7 FSOI activity is to identify priority activities for coordinated G7 support leading to improved marine life observing and forecasting capacity. This will require broad consultations across G7 Member programmes, GOOS, MBON, IODE, OceanPredict, and relevant Decade programmes to identify priority activities that contribute to developing standardized species and ecology observations that can be integrated into existing and planned ocean and seas observing programmes, and to improve modelling and forecasting capacity to address critical needs for global sustainable development indicators. Many of these activities represent the fundamental underpinnings required for a Digital Twin Ocean to address marine life.

Further, this G7 FSOI activity should work with the emerging communities of practice addressing marine life observing and forecasting ***to respond to G7 Member needs for reporting on regional and global marine ecosystems and biodiversity as agreed in the Sustainable Development Goals as well as other UN and regional conventions.*** These include intergovernmental agreements such as the UN System of Environmental Economic Accounting, requirements for reporting on the status of biodiversity and ecosystems as part of the Convention on Biological Diversity post-2020 Global Biodiversity Framework, and new international agreements under development through the UN's Intergovernmental Conference on Marine Biodiversity of Areas Beyond National Jurisdiction. Direct engagement with these global, regional, and national policy drivers will ensure that observing and modelling / forecasting strategies stay focused on meeting the needs of stakeholders and G7 priorities.

G7 Member support for these national, regional, and global programmes and for their global coordination will contribute significantly to transformational changes during the Decade. The groups consulted have identified the following areas where a G7 FSOI activity could make significant contributions:

A. Advancing Stakeholder Engagement and Co-Design of Ecosystem Service Solutions for the Blue Economy

The G7 FSOI is well-placed to foster the necessary linkages between the observing system, government representatives, major blue economy stakeholders and user groups, natural scientists, and social scientists to identify critical ecosystem services and advance the co-design of integrated observing and data and information management solutions to ensure sustainable development, restoration, and conservation of these services. ***The goal of this activity is to encourage, facilitate, and support the identification of stakeholder needs for marine life monitoring and forecasting, identify the intersection with G7 priorities and global and regional policy drivers, and encourage the development of observing and forecasting strategies that are also useful to and inclusive of developing nations and specifically Small Island Developing States.*** This stakeholder-engagement approach would aim to develop the ability to forecast species and ecosystem services with an emphasis on societal-benefit issues such as the inter-dependence of local life and climate change and links to food security, ocean and human health, the economy and jobs.

B. Data Archaeology and Mobilization of Marine Biodiversity Data

The fastest and most cost-effective way to generate the information required to develop baselines in data-sparse areas and to improve our ability to forecast how marine biodiversity will change in response to the changing environment is to mobilize (identify, digitize, and make accessible) the information that nations have already collected. However, a significant amount of marine biology and biodiversity data exists solely in publications or in specific researchers' databases and is not publicly accessible, even in G7 countries. This creates a hurdle for research, management, and decision-

making on very basic questions about marine life, including those pertaining to biodiversity, status and trends, and species range shifts due to changing ocean conditions.

The G7 Members should 'lead by example' in this area by setting a coordinated joint action to identify and make available their existing biological and ecosystem data to develop a coherent global picture of past and current changes in marine biodiversity. Through a coordinated G7 FSOI task team, G7 national focal points and experts could be empowered to seek partnerships with academia, government, and private sector data holders, and act as leaders of a broader regional response to increase the impact of this initiative. Working in collaboration with data sharing and modelling / forecasting programmes, these data may be transformed into standardized formats and integrated into OBIS (*see Section C, below*).

Further, a G7 FSOI task team could work with governments beyond the G7, scientists, and industry to seek joint novel technologies and codes of practice to rescue existing data that are not available to national or global databases. Big data and Artificial Intelligence approaches for marine biodiversity would allow new ways to examine information across the globe. A global effort as part of the UN Decade of Ocean Science for Sustainable Development and Ocean Literacy activities could crowd-source data entry of standardized marine biology data into central, global, public, and widely accessible repositories.

C. Developing Capacity for Interoperable Biodiversity Data Standards

As the best-resourced countries in the world, the G7 Members should also 'lead by example' in this area by ***adopting and using existing, advanced data standards to harmonize marine biodiversity / ecosystem and environmental data. This includes the co-development of guidelines for data collection, management, and sharing of biological and ecosystem Essential Ocean Variables***. G7 Members can also provide international leadership advocating for and supporting the development of additional, fit-for-purpose standards and best practices where needed.

The most effective approach is to work with and support the appropriate international / intergovernmental programmes addressing these issues, with a collaborative focus on biology and ecosystem data standards. In 2020 (and under covid conditions), IODE's OBIS increased with 20 million new occurrence records, 100 million new measurements and 1,000 new datasets. The growing success of OBIS and the rise of expectations for OBIS to support new initiatives of GOOS, MBON and a growing number of Decade programmes will require extra resources both at the national level (e.g., support for OBIS nodes, particularly those of G7 Members), as well as support for the international secretariat under IOC of UNESCO, which currently is only supported by a part-time project manager (permanent) and one part-time data manager/IT engineer (temporary position, project-based).

D. Expanding Observations of and Forecasting Skill for Global Marine Biodiversity

Augmenting existing ocean and coastal observing and information management infrastructures is required to significantly advance ecosystem-based management in a changing environment. This includes augmenting the spatial and temporal coverage of standardized biological and ecosystem Essential Ocean Variables (EOV) and integrating these observations with relevant satellite observations and ecosystem models.

This G7 FSOI activity should encourage and support the GOOS Bio/Eco Expert panel to bring together programmes addressing marine life observations with relevant modelling and forecasting programmes such as OceanPredict, CoastPredict, and Decade programmes to identify where enhanced bio/eco EOV sampling on existing infrastructure would have the greatest impact and to develop optimal sampling strategies (and identify priority regions) for new and existing biological and ecosystem observations, considering satellite observations, data assimilation and modelling / forecasting. G7 Members are already leading the way on these and other regional and global coordination programmes, including major initiatives in North America

(US MBON; MBON Pole to Pole in the Americas; Smithsonian MarineGEO) and Asia Pacific (Asia Pacific MBON). MBON and the GOOS Bio/Eco Panel are working together and seek broader engagement to form a global community of practice that can coordinate regional efforts into a coherent global action. They have been recognized by the High-Level Panel for a Sustainable Ocean Economy as having the leadership role to advance priorities for biodiversity governance and coordination of marine biodiversity observations at the intergovernmental level.

Significant advances in marine life observations will also require partnerships between observing system developers and government and industry partners to co-design lower cost and ***autonomous technologies to monitor life in the sea***. Technologies under development include omics, imaging, acoustics (passive and active), artificial intelligence for automatic identification of species and standardized data formatting for immediate sharing. In addition, new 'smart' biogeochemical observing systems on autonomous vehicles driven by assimilative model forecasts will greatly improve the effectiveness of observing platforms. These technologies must be more fully developed and integrated with operational ocean observing programmes such as repeat hydrography (GO-SHIP), including development of data management, sharing, and assimilation technologies for ocean forecasting. The G7 FSOI working group identified sensor technology as a priority but noted that this was an area where G7 members could make significant contributions through national programmes rather than coordinated joint action. However, ***documenting the G7 member activities in sensor and technology development for biological and ecosystem variables and linking these activities more closely to stakeholder engagement activities, and observing system and data infrastructure development*** would add significant value.

2. DESCRIPTION OF THE ACTIVITY AND NEXT STEPS

This G7 FSOI activity would identify programmes and actions in marine life observations, data management, modelling and forecasting, and stakeholder use / engagement that represent the pillars of a global observing and forecasting system for marine life, and encourage and mobilise sufficient G7 financial commitment, implementation-tracking, and international visibility to make them viable.

The Task Team would work principally with the GOOS Bio/Eco Expert Panel and its communities of practice to:

1. Support and strengthen existing efforts in community building and coordination, including the Marine Biodiversity Observation Network (MBON), GEO Blue Planet, and the international Marine Life 2030 Ocean Decade Programme to advance these goals.

2. Document global and regional policy drivers (e.g., UN and regional conventions and agreements) and their needs for regular information on metrics or indicators on species and ecosystem services, as well as operational forecasting needs for marine life data.

3. Promote the awareness, adoption, and use of existing data standards for marine biodiversity data, where guidelines for data collection, management and sharing of biological and ecosystem variables have been agreed to by existing international communities of practice.

4. Encourage coordinated data archaeology, mobilisation, and rescue activities for marine biodiversity data, aimed at identifying, digitizing, and making accessible unshared / unpublished marine biodiversity data, for the benefit of G7 stakeholders and in partnership with academia, government, and private sector data holders, and act as leaders of a broader regional response to increase the impact of this initiative.

5. Advocate for and support the development of data standards and best practices for Essential Ocean Variables (EOV) in collaboration with the appropriate international / intergovernmental programmes. Encourage and support sensor and technology development to advance bio/eco EOV observations.

6. Support and promote data sharing infrastructure activities, Decade programmes, and global communities of practice that represent the pillars of a marine biodiversity observing system that builds on optimal integrated observations from satellite and in situ observations, data assimilation, and modelling and forecasting capability.

7. Encourage and support the design, coordination, and implementation of regional observing capacity development and training efforts, in partnership with (*inter alia)* GEO Blue Planet, the Partnership for Observations of the Global Ocean, the IOC, WMO, and Ocean Decade Programmes.

To take this forward, a G7 FSOI-sponsored workshop is needed to identify priorities and guide system development, including (for example) to:

- document the programmes and communities that could contribute to G7 priorities, and identify capacity, gaps, benefits and incentives for expanded biology and ecosystem observations and forecasting,
- plan a data mobilization initiative to increase availability of existing biodiversity data,
- advance and promote the adoption of standards and best practices for data management,
- foster linkages to data assimilation and climate and ecosystem modelling efforts,
- design, coordinate, and facilitate capacity development activities focused on training on standardized methods for marine life observations and data management, and
- develop a resource plan to guide financial support for G7 priority areas, and for G7 priorities of the relevant Decade programmes, including the central pillar programme OBIS and its operations in regional nodes and the international office.

Deliverables:

Workshop report(s) documenting (*inter alia*) priority G7 stakeholder needs for marine life observations (global and/or regional) and data / information products and tools; an evaluation of existing capacities for marine life observation and forecasting; priorities and opportunities for augmenting existing observatories and ecological forecasting activities; identification of priority gaps in observations, modelling and forecasting, and technology development; guidelines for biodiversity data mobilisation and rescue activities; and capacity development proposals for system co-design, local engagement including indigenous knowledge and local knowledge systems, and training. The reports will identify leads, commitments, and resources needed to enable collaborative activities, and opportunities for investment in each of these areas to advance the Ocean Decade.

A resourcing report to inform and guide coordinated joint support by G7 Members for priority Decade programmes, organizations, and activities.

Regular reports to the G7 Members on plans and implementation tracking in the development of the observing and forecasting system for marine life, and proposals for targeted, value-added activities, pilot projects, or demonstrators where the G7 Members could work individually and collectively to advance the observing and forecasting system development.

A mechanism, through the GOOS Bio/Eco panel, to provide the information required by G7 Members for reporting to UN and regional conventions.

3. RESOURCING FOR THE G7 FSOI TASK TEAM

For the first phase of the Task Team work:

Estimate 20% FTE support by G7 FSOI Coordination Centre to establish the Task Team, guide and facilitate its work, and communicate regularly with G7 members and stakeholders.

Estimate < 2% FTE in-kind support from each G7 Member to ensure engagement and communications with respective national and regional experts and programmes.

Estimate $50K USD for an initial start-up planning workshop if in-person; funds requested for invited experts (especially regional and LDC / SIDS representatives); with additional G7 member support for the participation of their own experts and representatives.

ANNEX – International programmes involved in scoping this activity:

The ***Marine Biodiversity Observation Network (MBON)*** is a global community-building initiative that welcomes regional networks of scientists, resource managers, and end-users working to integrate data from existing long-term programs to improve our understanding of changes and connections between marine biodiversity and ecosystem functions. Benefits of MBON include: Providing best practices and mechanisms to share data, experiences, knowledge, and protocols to understand species and the status and trends of ecosystem services and providing a framework for a region or a country to evaluate status and identify trends in biodiversity and living marine resources.

Marine Life 2030 (ML2030)*: A Global Integrated Marine Biodiversity Information Management and Forecasting System for Sustainable Development and Conservation* aims to establish a globally-coordinated, operational system to deliver actionable, transdisciplinary knowledge of ocean life, promote human well-being, sustainable development, and ocean conservation. The ML2030 programme will build on existing and frontier technologies and coordinate partners into a global, interoperable network and community of practice to advance observation and forecasting of marine life. The ML2030 programme will also develop a linked network for efficiently sharing and implementing interoperable protocols and open data on status and trends of marine life globally.

The ***Ocean Biomolecular Observing Network*** (***OBON***). Ocean life - from viruses to whales - is built from 'biomolecules'. Biomolecules such as DNA infuse each drop of ocean water, grain of sediment, and breath of ocean air. The OBON will develop a global system that uses techniques to analyse biomolecules such as DNA, RNA, and proteins (e.g., eDNA analysis, metabarcoding, omics) to greatly enhance coastal and open ocean biodiversity observations. We exploit the fact that every lifeform in the ocean, from viruses to the largest marine mammals, contains or leaves behind a biomolecular trace (e.g., nucleic acids) that can be analysed directly from a tissue, seawater, or sediment sample. The programme will utilize biomolecular technologies to monitor, research and understand life in the sea at every trophic level and scale, how life varies in response to climate and anthropogenic impacts, including fisheries, and how these changes impact society. The programme will also develop capability through the collection, analysis, and archival of biomolecules (e.g., nucleic acids) and reference samples using both autonomous and manual collections from fixed locations or grids where measurements of biological, biogeochemical and for the medical diagnostics industry and eventually deploy a global network of autonomous platforms with biomolecular sensing capability that will greatly expand the foot-print of the fixed locations. This autonomous platform network will provide persistent synoptic observations of the biology of the ocean analogous to the physical measurements of the Argo network.

Deep Ocean Observing Strategy (***DOOS***) Decade Science Plan will work to augment biological and ecosystem measurements on existing or new infrastructure, and to bring together the modelling / forecasting community with the biological observing community to improve predictions of marine life, as well as use models to inform observation strategies. DOOS is being developed as a project of GOOS and coordinates many other biological deep-sea programs in an international framework that brings together the broad range of expertise required to identify the challenges and seek solutions that will advance our understanding of and maintain the functioning and services of the deep ocean.

Deep Ocean Stewardship Initiative Challenger 150 is a global scientific cooperative developed to respond to the needs of the Decade following on from the Census of Marine Life with goals to build capacity for deep-sea research globally, expand deep-sea biological observations and sampling in all ocean basins, specifically focusing on underexplored regions, build fundamental ecological understanding of deep-sea ecosystems including ecosystem services delivered by the deep seas and flows of benefits to society, and increase use of deep ocean knowledge through development of effective 'knowledge to end-user' pathways, including use of decision-support tools in modelling deep sea management scenarios.

The Ocean Biodiversity Information System (OBIS), developed in 2011 as a project of the IODE to continue the work initiated by the Census of Marine Life, is recognized by the IOC's Member States as the global open-access data and information Clearing-House on marine biodiversity for science, conservation and sustainable development. OBIS is a network of scientists and data managers, united through 32 regional, national, and thematic OBIS nodes, who work collectively to publish quality-controlled marine species occurrence data and the environmental data collected simultaneously, in the public domain, which then gets integrated into a single

dataset by OBIS. OBIS supports global and regional assessments and provided the statistics on the trends in marine biota as well as the state of biodiversity in marine habitats in the 2nd UN World Ocean Assessment.

The OceanPredict ForeSea Programme has a vision of strong international coordination and community-building towards an ocean prediction capacity for the future. The overarching goals are to (1) improve the science, capacity, efficacy, use, and impact of ocean prediction systems and (2) build a seamless ocean information value chain, from observations to end users, for economic and societal benefit. The Programme aims to make ocean prediction science more impactful and relevant, and to strengthen integration of biogeochemical and ecosystem models into existing ocean operational systems. The Decade project ***Synergistic Ocean Observing Network for Impactful and Relevant Ocean Prediction (SynObs)*** project will support several UN Decade Programmes to find the optimal constellations of satellite and in-situ observations (best density and sampling strategy for satellite and in-situ observations for efficient and well-balanced data assimilation); identify and capitalise on synergies between satellite and in-situ observation data assimilation; show benefit of collocated observations**;** find combinations of coastal, open-ocean and satellite observations optimal for coastal predictions via down-scaling approaches; and find combinations between physical and BGC observations and improve the ability of ocean prediction systems to represent biogeochemical properties of the ocean. SynObs has been developed and will be supported by the ***OceanPredict Observing System Evaluation Task Team (OS-Eval TT)****.* In addition, the ***OceanPredict Marine Ecosystem Analysis and Prediction Task Team*** (MEAP-TT) works to develop the underpinning science and tools required to further the integration of biogeochemical and ecosystem models into existing ocean operational systems. The MEAP TT's mission is to advocate for an expansion of the ocean observing system with respect to biogeochemical and biological properties, to support method development for the assimilation and modelling of Essential Variables, to share scientific advances and the transfer of capabilities between academic and operational centres of expertise, and to help bridge the gap with end-users. MEAP-TT works in synergy with the ***OceanPredict Coastal Ocean and Shelf Seas Task Team (COSS-TT)*** that focuses on science in support of physical and ecosystem forecasting in the coastal areas, shelf and marginal seas, and their seamless integration with the open sea observing and forecasting.

The GOOS co-sponsored Decade Programme ***CoastPredict*** will work globally to upgrade to a fit-for-purpose oceanographic information infrastructure and will lead the co-design and implementation of an integrated coastal ocean observing and forecasting system adhering to best practices and standards, designed as a global framework, and implemented locally. CoastPredict already coordinates 35 countries around the world, with a large participation of leading G7 oceanographic Institutions as well as international organizations. CoastPredict will transform the science of observing and predicting the Global Coastal Ocean, from river catchments, including urban scales, to the oceanic slope waters. It will integrate observations with numerical models to produce predictions with uncertainties from extreme events to climate, for the coastal marine ecosystems (their services), biodiversity, co-designing transformative response to science and societal needs. CoastPredict has developed synergies with several international initiatives, such as OceanPredict and in, particular, its COSS-TT and OS-Eval TT (SynObs is a joint project with CoastPredict).