A Roadmap for the Implementation of the Global Ocean Observing System 2030 Strategy

for an open planning process

April 2020
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Foreword from GOOS

The demand for sustained ocean observations, from both in and above the ocean, is increasing rapidly, as are the requirements for ocean information. The Global Ocean Observing System 2030 Strategy provides the vehicle to meet expanding and urgent societal needs. The strategy is ambitious. It envisions a fully integrated global observing system ranging across the value chain that extends from observations, through data management systems, scientific analysis and forecast, to end users via information, data and decision-making services. GOOS will need develop strong partnerships to ensure the observing system delivers the information needed, and to build new advocates for sustainability.

Under the 2030 Strategy, the eleven Strategic Objectives provide guidance on priorities for the development of a more user-focused and integrated system, and for the core work of GOOS itself. Objectives under the goal of “system integration and delivery” have historically been the core of GOOS, while the objectives related to “deepening engagement and impact”, and “building for the future,” will demand a step change in the level and effectiveness of partnerships across the value chain, from observations to end use and in areas outside GOOS core work, including technology, human impacts and capacity development.

This Roadmap is designed to provide a framework within which nations, partners and sponsors can envision actions towards achieving the 2030 Strategy. It will be a co-design process and we anticipate an evolving document focused on both the GOOS Programme and our partners’ actions. We also anticipate evolving the governance for an expanded observing system.

We hope that this Roadmap will help guide the priorities and the way forward for the global community. This document, and the actions it generates, will depend on your input. We strongly encourage you to provide feedback.

Toste Tanhua
Co-Chair, Global Ocean Observing System Steering Committee
Figure 1: An integrated ocean observing system that operates from the open ocean to the coast, and includes initiatives from local, national, regional and global organisations. With integration across physical, chemical and biological realms, to serve the needs of users from climate, operational services, and ocean health. It works towards Integrated delivery chains that connect observations to data management, modelling, assessments and other providers of information and services to end-users.
SCOPE

The Global Ocean Observing System 2030 Strategy identifies a vision for a truly integrated global ocean observing system that delivers the essential information needed for our sustainable development, safety, wellbeing and prosperity. Implementing this ambitious strategy will require broad partnership from science, industry, government and user communities, as well as a deep commitment to building human capacity and a strong multidisciplinary approach.

The 2030 Strategy builds on the visionary Framework for Ocean Observing, strengthening the areas that have not yet been fully implemented, including partnership to support delivery of the essential information being sought by society, and broadening the delivery of the system to fully encompass the 3 core delivery areas: operational services, climate and ocean health.

This document is an initial Roadmap for the Implementation of the Global Ocean Observing System 2030 Strategy. It is a working document and intended to initiate a dialogue with partners across the observing system enterprise on how we can work together towards achieving this vision. It provides an open framework into which current and future partners can identify roles and areas in which working together will support the implementation and sustainability of a fully integrated ocean observing system.

The Roadmap adds substance to the eleven Strategic Objectives of the 2030 Strategy, laying out the issues, implementation ideas, and highlighting how they will act together to guide development of an integrated system. Some of the Strategic Objectives encompass core GOOS Programme activities, others will likely be led by partner organizations—achieving the strategy will require cooperation, coordination and the commitment of many organizations and entities beyond the core of GOOS. It will also require a new system of governance.
Figure 2: The Goals and Strategic Objectives of the Global Ocean Observing System 2030 Strategy

- Open data
- Support innovation
- Guide capacity development
- Observe human impacts
- Champion effective governance

System integration and delivery

- Strengthen observing implementation
- Authoritative guidance on design
- Empower end user applications
- Evaluate impact
- Advocacy and communication
- Strengthen partnerships for delivery

Deepening engagement and impact

Building for the future
STRATEGIC OBJECTIVES

The Global Ocean Observing System 2030 Strategy defines 11 Strategic Objectives, under three overarching goals:

Goal: Deepening Engagement and Impact

Deepen engagement and partnership from observations to end users to advance the use and impact of the observations and demonstrate their benefits.

SO1. Strengthen partnerships to improve delivery of forecasts, services, and scientific assessments.

SO2. Build advocacy and visibility with stakeholders through communicating with key users and national funders.


SO4. Strengthen knowledge and exchange around services and products, to boost local uptake.

Goal: System Integration and Delivery

Deliver an integrated, ‘fit for purpose’ observing system built on the systems approach outlined in the Framework for Ocean Observing.

SO5. Provide authoritative guidance on integrated observing system design, synthesizing across evolving requirements and identifying gaps.

SO6. Sustain, strengthen and expand observing system implementation through GOOS and partner communities, promoting standards and best practice, and developing metrics to measure success.

SO7. Ensure GOOS ocean observing data and information are findable, accessible, interoperable, and reusable, with appropriate quality and latency.

Goal: Building for the Future

Building for the future through innovation, capacity development, and evolving good governance.


SO9. Develop capacity to ensure a broader range of beneficial stakeholder participation.

SO10. Extend systematic observations to understand human impacts on the ocean.

SO11. Champion effective governance for global in situ and satellite observing, together with partners and stakeholders.
To provide impetus for action, delivery and evaluation, we propose that the 2030 Strategy partners work together towards achieving some clear outcomes in the medium term (3 - 5 year timeframe), that will have impact on three delivery areas and represent concrete steps towards achieving the 2030 Strategy.

Below some initial ideas are proposed for these impact outcomes and what targets could look like. These initial ideas are open for discussion, input and adjustment in the coming months. It will be important align them with the key outcomes from OceanObs’19 and the strategic objectives of our partners. Some of the targets for impact could lay the foundation for Initiatives under the UN Decade of Ocean Science for Sustainable Development 2021-2030 (“Ocean Decade”), and others could support the development of indicators for the Convention on Biological Diversity (CBD) Post-2020 Biodiversity Framework. The overarching aim is that they stretch across Strategic Objectives and drive implementation of the 2030 Strategy with measurable impact towards delivering essential information. We can deliver greater impact by working together.

**Climate**

1. **Design and implement an observing system to assess the ocean climate in target areas:**
   - Target 1.1: Quantification of carbon net flux of ocean and coasts to +/- 10% on an annual basis, and the interior carbon inventory to +/- 10% on a decadal basis.
   - Target 1.2: Quantification of the deep ocean energy budget
   - Target 1.3: Quantification of the ocean heat content
   - Target 1.4: Quantification of the sea level

2. **Deliver ocean information to improve the response and adaptation of coastal communities:** implement through pilots to assess effectiveness, in partnership with coastal planners, engineers, and investors.
   - Target 2.1: Implement pilot on sea level rise.
   - Target 2.2: Implement pilot on ocean acidification.
   - Target 2.3: Implement pilot on habitat loss.

3. **Design a global ocean observing system to assess the impact of climate change on ocean ecosystems**

4. **Operational Services**

4. **Develop basic service infrastructure:** delivering consistent information from models, at global scales and for the main basins
   - Target 4.1: Real-time description and forecasting of the physical and biogeochemical state of the ocean
   - Target 4.2: Multi-year description of the physical and biogeochemical state of the ocean over the past decades
   - Target 4.3: Common set of standards and validation metrics for interoperability and cross-assessment of ocean information

5. **Improve forecasting of high impact events for society and the blue economy:** through enhanced ocean observations, model improvement, and an earth system approach.
   - Target 5.1: Coastal flooding and waves, extreme sea level
   - Target 5.2: Severe storms, tropical cyclones including a responsive component of the ocean observing system to provide essential information ahead of a predicted event
   - Target 5.3: Extreme ENSO
   - Target 5.4: Marine heat waves
6. **Optimise the interface between open ocean and coastal observing systems:** to support improved coastal forecasting
   - Target 6.1: African pilot for services from a connected, integrated and sustained ocean observing system around the African continent, with a focus on information to support a sustainable marine economy
   - Target 6.2: Ocean acidification
   - Target 6.3: HABs.

**Ocean Health**

7. **Five ‘global’ biological and ecological (BioEco) observing networks implemented:** with all five at least to a pilot stage in all network attributes¹.
   - Target 7.1 Agreed implementation plans in place with Best Practices identified and gaps prioritised for capacity development
   - Target 7.2 Data flow and agreements in place
   - Target 7.3 Regular monitoring outputs available to support specific clients and meeting FAIR and open standards

8. **Improved delivery of essential ocean information to indicators for conventions:** a step change in ocean observing capacity for assessing performance against the UN Sustainable Development Goals and Convention on Biodiversity post-2020 targets.
   - Target 8.1: Consolidate EOVs and ECVs and depths from the coastal margins to the deep sea
   - Target 8.2: Match EOVs to national and global reporting and develop specific delivery products and pathways to uptake
   - Target 8.3: Identify and develop EOV products to support investment in conservation, restoration and sustainable use

9. **Implementation of new human activity/impact EOV observing systems:** to at least a pilot stage in all network attributes², with connection from observations to users.
   - Target 9.2: Pollution including oil spills
   - Target 9.3: Ocean Sound including shipping

These initial ideas are designed with a focus on priorities for societal needs, a second version of the Roadmap in summer 2021 would include revisions to the impact areas and targets, and information on which partners will support them. Not all the targets proposed as initial ideas will be adopted. Targets could be met through action areas under GOOS, as initiatives with partners, some could be developed outside of GOOS through partner or as projects with specific support. Progress will be tracked and the impact on end users evaluated, with progress reported to partners and the broader community.

¹ See the Observation Coordination Group (OCG) list of ‘Attributes of an OCG ‘global’ Observing Network, as a guide – on this link. BioEco attributes list is being published

² See the Observation Coordination Group (OCG) list of ‘Attributes of an OCG ‘global’ Observing Network, as a guide – on this link. BioEco attributes list is being published
Since 1991, GOOS has created an extensive global system, based on contributions from a large number of organizations and nations, from which nations and people all over the world benefit. In its first decades, GOOS coordinated the development of a global ocean observing system designed to support climate science and to serve as the observational backbone for operational forecast systems. This success, coupled with growing concerns about the health of oceans and demand for information products to help nations manage their ocean economies, sparked development of the visionary Framework for Ocean Observing³, a prime outcome of the OceanObs’09 Conference. 

GOOS has led the implementation of the framework by the ocean observing community, with the goal of serving users across climate, operational services and ocean health, increasingly with a focus on coastal areas and regional seas.

Today, GOOS has six key components:

- Governance through a **GOOS Steering Committee and sponsors** (the Intergovernmental Oceanographic Commission of UNESCO, the World Meteorological Organization, United Nations Environment Programme, and the International Science Council);
- Core coordination through a central **GOOS Office** in Paris and distributed nodes supporting GOOS structures and engagement. A G7 GOOS Coordination Centre operates to complement this;
- **Expert panels** for physics and climate, biogeochemistry, and biology and ecosystems, that synthesize across requirements and provide guidance on observing system design and Essential Ocean Variables (EOVs);
- **The Observations Coordination Group, JCOMMOPS, the GOOS Regional Alliances, and the global observing networks** that implement observing systems and ensure the flow of observations across networks and regional observing structures;
- **An expert team on operational ocean forecast systems** creating guidance to improve capacity, quality and interoperability of ocean forecast products;
- **GOOS Projects** that advance innovation and expand into new areas and capabilities for the observing system, service and product delivery through operational and other service providers;

GOOS and the Framework for Ocean Observing

Policy, adaptation, safety of life and property ecosystem resilience

Figure 3: Diagram of the current (2020) GOOS components following the Framework for Ocean Observing. The structure of GOOS and our partnership with other organizations will need to evolve in order to achieve the 2030 Strategy, the current structure is not sufficient to support all the Strategic Objectives.
GOOS core principles have been constant since 1998⁴ and are upheld through the implementation of the Strategic Objectives:

- Implement through user-driven design;
- Maintain sustained observations;
- Ensure regular evaluation;
- Set global standards and best practices;
- Encourage open data sharing;
- Develop capacity

GOOS already plays an essential role in coordinating the world’s distributed ocean observing systems and community, which encompasses local, national and regional ocean observing systems and programmes, principal investigators, scientists and technicians undertaking sustained observations within national programs and global ocean observing networks, and the many individuals contributing to the GOOS components. Together with this broad ocean observing community, we will continue to provide a pathway for the evolution of the integrated global system and in particular for ensuring that it meets the needs of the diverse array of end-users. We will however need help to achieve the ambitious vision of the 2030 Strategy. Achieving this ambitious vision cannot be the sole responsibility of the GOOS community. It requires the commitment of many other actors, in the private and public sectors, working at global and local scales, in the ocean and from space, coordinating and evolving together.

The GOOS mission within the 2030 Strategy is ‘To lead the ocean observing community and create the partnerships to grow an integrated, responsive and sustained observing system’.

To meet the challenge of the 2030 Strategy, GOOS will need additional resources to support the management of partnerships, to develop communications and to support an expanding ocean observing enterprise.

⁴ GOOS Strategic Plan, 1998, GOOS-41, goosocean.org/goos-41
This Roadmap is a first step in engaging with partners and the observing community to achieve the vision of the 2030 Strategy. We encourage partners to consider the Strategic Objectives and what role they could play in supporting or leading on these.

The GOOS Programme is actively working on its implementation towards these Strategic Objectives, this is captured more fully in the current GOOS Implementation Plan (www.goosocean.org), which evolve with the roadmap.

Governance of the full span of activities encompassed in this Roadmap, many of which will be in conjunction with or even led by partners, will require the evolution of present governance arrangements. Evolving the governance of the ocean observing system will lead to greater partner involvement, improved cooperating, communicating, and support the evolution of future Roadmaps.

**Figure 4**: Observations generate value for science or end users making decisions through a value chain, where each step add value to the basic observations. These run from observations through data management, analysis forecasts or models, services and applications, which provide information of value to end users in making short or long-term decisions of societal importance. Science is an important intermediate user, and research and innovation actions underpin the development of stronger value chains.
GOAL: DEEPENING ENGAGEMENT & IMPACT

Deepen engagement and partnership through the value chain from observations to end users, in order to advance the impact and use of the observations, and to improve visibility of the work of the observing system.

Meeting the four strategic objectives under this goal will require increased partnership along the value chain, and the development of feedback loops from service providers to help refine system design.
SO1. Strengthen partnerships to improve delivery of forecasts, services, and scientific assessments

Issue
There is a fundamental lack of connection across the value chain, from observations to end use (see Figure 4), and therefore in our ability to implement end-to-end design and ensure fit for purpose delivery of essential information, and the ability of the system to be responsive to users.

Implementation
Building on existing partnerships with the global climate research and marine services community, GOOS and the community will work on strengthening engagement with new and existing partners to improve the interfaces from ocean observing networks and data systems, to key intermediate users across climate, operational services and marine ecosystem health applications. Partnerships will be established with key ‘intermediary’ users (organizations that deliver aggregated information to serve a broad range of end-users) in order to support end-users in areas that have a high societal impact and to enhance the value chain from observations to end use. We need to make a major leap forward in establishing partnerships to link sustained observations and scientific assessment to maintain and improve vital coastal and ocean ecosystem services. GOOS will work with its partners on developing a reporting capability, in order to track progress, see Strategic Objective 3 (SO3). Existing and potential partners are encouraged to consider how we can more effectively collaborate to improve delivery and resourcing to work with GOOS.

Outcomes
- A strengthened, responsive and delivery-focused observing system;
- Established strong partnerships with key intermediary user organizations across climate, operational services and ocean health delivery areas
- An increase in fit-for-purpose ocean information products (forecasts, indicators, coastal warning) based on sustained observations
- Ability to evaluate system for adequacy in meeting societal needs (also see Strategic Objective 3 – SO3)
- Improvement in the sustainability of the observing system individual components, through clarity on how observational data contributes to providing critical services

Role of GOOS (to stimulate discussion)
GOOS will actively develop partnerships with key organizations and communities to develop connection and feedback loops along the value chain, initially concentrating on data delivery to key intermediate service providers and areas that are high societal priorities. The ocean observing community will be encouraged to support and contribute to these connections. GOOS will additionally. The GOOS expert team on operational ocean forecast systems (ETOOFs) will play an important role in connecting observations to these key intermediate end users for ocean and weather forecasting services.

Potential partners (to stimulate discussion)
The World Meteorological Organization (WMO), through its Member National Meteorological and Hydrological Services, and National Ice Services are key delivery partners for weather, maritime and climate services. The global modelling community is a key partner across all delivery areas, with OceanPredict a key partner in global modelling innovation and advancement. The Convention on Biological Diversity is a key partner where Essential Ocean Variables will support the post-2020 Biodiversity Framework. The key super or intermediary users need to be identified to help prioritize and enhance information delivery to end-users. Regional organizations focused on delivery to a broad range of users, such as Copernicus Marine Services (CMEMS), are also vital partners. In each delivery area there are different key partners.
SO2. Build advocacy and visibility for the observing system with stakeholders, communicating with key users and national funders

Issue

The ocean observing system is predominantly funded through national investment, which is often fragmented across a variety of different funding sources, and is largely dependent on successive short-term research projects. Knowledge of the economic value of the services it enables is scattered and not well defined. Major satellite and basin-scale in situ observing networks depend on funding from a very small number of countries. There is a fast growing need for: more nations to step up and support the system, for better understanding of the value of ocean observing and its contribution to sustainable economies, human health and safety, by politicians and the public. There is a need to advocate for long term thinking around funding mechanisms to support ocean observing.

Implementation

GOOS will work towards ensuring greater visibility for the vital work undertaken by the observing community and the value it provides, in particular targeting policy makers and funders. One component of this will be to gain a better understanding of the economic and socioeconomic value of ocean observations, through quantifying the impact of services at the end of the value chain. Through the Intergovernmental Oceanographic Commission (IOC), GOOS is in a unique position to be an advocate into international processes for sustaining essential observations, and to strengthen our vocal advocates within national agencies and organizations. GOOS will seek to understand and reduce the risk to the sustainability of the observing system depending
on large individual and short-term national contributions through all levers possible, including advocacy, collaboration agreements and capacity development. This is an area that all parts of the ocean observing enterprise can work towards, and GOOS can support by providing the community with information, materials and a platform for a common voice to help make the case at the appropriate funding levels. Nations in particular can support this effort through creating focal points within government for ocean related issues - ocean ambassadors or ocean programmes. The partners in Strategic Objective 1 (SO1) can strengthen the system through highlighting the role of observations and the value chain within their applications and services.

Outcomes

- Significant step-up in the external recognition of value of the global ocean observing system in climate, operational services, and marine ecosystem health areas
- An increase in longer-term sustained funding for ocean observations and an external vocal community who are advocates for the need for sustained ocean observation
- Increase in nations participating in the observing system
- An observing system that meets national, regional and global needs
- Recognition for the role that GOOS, WMO, IOC, and our partners play in supporting the global development of an ocean observing system

Role of GOOS (to stimulate discussion)

GOOS requires expertise and resource to develop and execute a communications plan. The GOOS Office will strengthen two-way communications with GOOS National Focal Points. An ongoing joint Organisation for Economic Co-operation and Development (OECD)-GOOS Project on the value of ocean observations, will provide needed insight for dialogue on the value of observations. The GOOS Regional Alliances are working to develop a collection of user stories that illustrate the economic value of ocean information. There is also a need to better link regional initiatives that have objectives in common, these include the GOOS Regional Alliances, International Oceanographic Data and Information Exchange (IODE) Ocean Teacher nodes, United Nations Environment Programme Regional Seas and IOC Large Marine Ecosystem initiatives.

Potential partners (to stimulate discussion)

Nations investing in ocean observing, from large to small and with well-developed or developing capability, to provide feedback on priorities and communications needs through the GOOS National Focal Points or other connections. Nations to be advocates for a fully integrated global system. IOC activities are important routes for advocacy, including Ocean Literacy. Other potential partners include organizations advising government, including Intergovernmental Panel Climate Change, European Marine Board, and others communicating on marine issues, such as GEO Blue Planet and EurOcean. Also, initiatives documenting the benefits of ocean information through use cases, for example the Copernicus Marine Services Blue Book. Finally, the United Nations Decade of Ocean Science for Sustainable Development is a strong advocate for the need for action to change the projected future for our ocean, on many levels, this can include advocacy for sustained observations as a core requirement.
SO3. Regularly evaluate the system to assess fitness-for-purpose

Issue

The Framework for Ocean Observing identifies the need for regular cycles of evaluation, at different levels: to ensure the data products coming out of the observing system meet the designed requirements, and to ensure that the information generated is having the impact on the societal issues that the system is designed for. At present, one framework for evaluation of global ocean observations for climate exists through the Global Climate Observing System and another through the WMO’s Rolling Review of Requirements⁵ process. However, we have little guidance to evaluate the observing system against other objectives, as a whole, or at regional and even local levels, and the components that exist are not connected.

Implementation

Working through the Framework process, GOOS and its partners will collaborate to undertake regular evaluations of how the observing system is delivering fit-for-purpose information for societal benefit areas and applications.

This assessment process will be guided by the requirements expressed against applications and knowledge challenges. The work GOOS has undertaken to develop the Essential Ocean Variables (EOVs), with scientific community input, forms a solid base and starting point for this effort, as do system reviews undertaken through GOOS Panels and Projects. Leveraging the work in Strategic Objective 1 (SO1) to develop partnership along the value chain, work in SO2 on the value of ocean observations, leveraging the work on Observing System Experiments/Observing System Simulation Experiment (OSE/OSSE) assessment studies with assimilative

⁵ https://www.wmo-sat.info/oscar/observingrequirements
models, and utilizing the independence of the GOOS Panels and Projects, in-depth system design analyses can be developed. These can be focused on addressing knowledge gaps across the three delivery areas to check fit-for-purpose of the entire delivery system. There is a lot of work to do under this objective and, as noted, some dependence on work in other objectives. We should anticipate longer timeframes for system wide delivery and look for key shorter term pilot projects as a first step.

Ultimately, GOOS should aim to have a series of measurable metrics to evaluate the performance of the system towards delivering to a range of user needs, across climate, operational services and ocean health, and provide guidance on performing evaluations for regional, national, or local needs. These metrics should capture the status of components of the value chain, from observing networks, to data flow, models, and the impact of the data on policy, governance, and public arenas. GOOS is far from having a comprehensive set of metrics, this objective will be implemented as Strategic Objective 1 (SO1) develops, and it is anticipated that these evaluations and metrics will evolve, as GOOS Projects and other innovation activities improve the capabilities of the system.

Outcomes

- Operational tracking of the observing system against targets for climate, operational services, and marine ecosystem health, understanding change in capability or quality and impact
- Identification of gaps across the observing system (disciplines and domains) and at global, regional, and local scales
- A view of the status of the observing system to meet societal goals, including real-time view of status for short term response
- Guidance on how to evaluate observing systems from a global, regional and national perspective
- Increased efficiency of information to evaluate the application of resources to meet requirements

Role of GOOS (to stimulate discussion)

Developing metrics to monitor observing capacity and performance through the Observation Coordination Group and BioEco Panel ‘global’ networks, with the support of JCOMMOPS. The initiation through the Observation Coordination Group (JCOMMOPS) of basin and later global visualizations of observing capacity against Essential Ocean Variables, Essential Climate Variables, and requirements from the WMO Observing Systems Capability Analysis and Review Tool (OSCAR). Using the joint Organisation for Economic Cooperation and Development (OECD)-GOOS project on the value of ocean observations to help in tracking where user impact can be measured.

Potential partners (to stimulate discussion)

Partners in modelling, assessment, and ‘intermediate’ users could greatly aid through providing feedback on what is required from the observing system - variables, latency, precision, coverage, etc., to improve services offered and assess the impact this work would have on the service levels provided target user communities. Creating a ‘system wide’ evaluation will take time and co-design with partners, in the first instance identifying pilot projects and partners willing to engage in shaping these evaluations is a first step. These partners should include global and regional organizations; WMO, IOC, OceanPredict (group on evaluation), World Ocean Assessment, Copernicus Marine Services, industry associations and providers of industry services, other organizations developing assessments and indicators.
**SO4. Strengthen knowledge and exchange around value creation from ocean observation, empowering the spread of end user applications at a local level**

**Issue**

Multiple national and regional investments have been made towards the development of products and services using ocean observations and forecasts. Although there are many successes, they are scattered across sectors, regions and stakeholders. Outside of weather forecast systems, there is no collective knowledge base regarding what ensures successful and value creating implementation of ocean data products and services.

**Implementation**

In order to help seed successful implementations of ocean products and services, GOOS will seek to identify existing and successful implementation, through GOOS Regional Alliances, regional and national systems, and partners; understand the nature of this success; and share this knowledge of best practice within product and service development. Beyond this, growing partnerships between the observing system and commercial organizations will be a key component of broadening the availability and range of products and services available, based on ocean data and forecasts. GOOS and the observing community can also strengthen its understanding of the value of ocean data through working with economic experts.

**Outcomes**

- Broader access and increased use of ocean data
- Increased innovation in ocean data services
- Building capacity and strengthening partnerships for delivery
- Improved decision making in the marine environment
- Enhanced impact for users of observing system at local/regional level

**Role of GOOS (to stimulate discussion)**

The GOOS Office and Regional Alliances will work together in identifying successful products and services, that can be linked to capacity development, best practice, and/or replicated in other regions.

**Potential partners (to stimulate discussion)**

Partners include ocean forecasting centres, companies providing services to the maritime industry, maritime industry associations and hubs, government business innovation initiatives, particularly Blue Economy focused and/or involving start-up incubation for marine information services. GEO Blue Planet is an important potential partner in this area with a focus on developing user interfaces and use cases for ocean data.
GOAL: SUPPORTING INTEGRATION & DELIVERY

Deliver an integrated observing system that is fit for purpose and built on a systems approach as outlined in the Framework for Ocean Observing.

The three objectives under this Goal 2 are at the core of GOOS current activity, stronger partnerships, particularly in data management and expanding our observing capability will be required to develop a fully integrated system, as well as increased transparency of process to facilitate co-design and engagement.

SO5. Provide authoritative guidance on integrated observing system design, synthesizing across evolving requirements and identifying gaps

Issue

The requirements for the ocean observing system are expanding rapidly, with users in different economic sectors requiring information at different levels of quality and latency. Creating individual observing systems focused on the needs of each delivery area is clearly not sustainable nor economic. An integrated global system needs guidance on design to maximize impact, balanced with the feasibility of implementing different options - both technical and for resourcing. The only clearly-stated global GOOS design responds to climate and is not yet fully integrated.
Implementation

GOOS will enhance its undertaking of multidisciplinary assessment and synthesis across a range of evolving requirements, in order to guide and support implementation decisions from global to regional, and across platforms, networks and technologies. This starts with an understanding of the needs for ocean information for public policy, government, citizen and private sector decision-making, to respond to questions related to our understanding of the complex whole earth system, and the information products and services that serve these applications. Requirements then are expressed against scientific or operational applications, the ocean phenomena, Essential Ocean Variables (EOVs), Essential Climate Variables (ECVs) and Essential Biodiversity Variables (EBVs), and time and space scales, that need to be sustainably observed to inform those applications defined; also considering the complementary design of satellite and in situ observing networks. Through cycles of assessment, defining requirements, providing implementation planning/guidance, and tracking, the design of the system is evolved. The process of triggering and supporting these reviews needs to evolve in the next years.

Outcomes

- Refined designs for observing the essential global observations required for global societal needs that maximize return on investment
- A modular design approach to guide and support implementation decisions at regional and national level
- Greater efficiency in investment towards enhancing observing capacity
- Transparency in establishing and communicating on design requirements

Role of GOOS (to stimulate discussion)

Authoritative advice is expressed through the EOV Specification Sheets and reviews from the GOOS Panels and Projects. The three GOOS Expert Panels provide scientific oversight on Physics and Climate, Biogeochemistry, and Biology and Ecosystems. They are involved in horizon-scanning and dialogue with the community over emerging areas of need for coordinated and sustained observations, and the subsequent development of EOVs and on focus areas for community evaluation and review. The GOOS Projects have a key focus on improving system design around specific areas. This is a part of GOOS current core coordination activity. The Observation Coordination Group global observing networks develop network targets and are influenced by the information and requirements identified in the reviews, as well as factors such as new technology, operational feasibility and resource. Current reviews include, the Tropical Pacific Observing System 2020 Review, the Heat and Freshwater Review.

Potential partners (to stimulate discussion)

Global Climate Observing System is a key partner for climate, with the Intergovernmental Panel on Climate Change (IPCC) Working Group 1 (The Physical Science Basis) and Working Group 2 (Impacts, adaptation and Vulnerability), and the United Nations Framework Convention on Climate Change (UNFCCC). The WMO, specifically the Integrated Global Observing System (WIGOS), Observing Systems Capability Analysis and Review Tool (OSCAR), the National Meteorological and Hydrological Services and ocean forecasting centres, are key partners for operational services. The development increased partnership in the value chain (Strategic Objective 1) will provide feedback on requirements from a user perspective and will strengthen the responsiveness of the system and its design to meet user requirements. The BioEco Panel works closely with the GEO BON Marine Biodiversity Observation Network (MBON) in integrating Essential Biodiversity Variables with biological Essential Ocean Variables. The Committee on Earth Observation Satellites (CEOS) and the Group on Earth Observations (GEO) for integrated design.
SO6. Sustain, strengthen and expand observations coordination through GOOS and partner communities, promoting standards and best practice, and developing metrics to measure success

Issue

The GOOS core system of ocean and marine meteorological observations is made up of many different observing platforms, sensors, techniques and communities. Together they have to respond to global, regional, and national requirements, and together deliver common data streams. Without coordination, opportunities for efficiency and knowledge-sharing between parts of GOOS are lost.

Implementation

This is a core activity for GOOS. Other organizations also coordinate various forms of observing networks, such as those around fisheries, ocean acidification, and environmental monitoring. Some of these use the GOOS coordinated infrastructure, some initiate and coordinate their own; however, all are clear partners in a fully integrated system, and there is much to be gained from greater collaboration in enhancing delivery and efficiency. Satellite constellations for remote ocean observing are also an important component for a fully integrated system and again an important partner. Individual nations and regions investing in implementing are already key partners in this objective. GOOS will build on coordination activity in the Observation Coordination Group (OCG), GOOS Regional Alliances, GOOS Projects, emerging observing networks and national systems, as well as activity within IOC. GOOS will also reach out to allied areas in fisheries, biodiversity, and the satellite community to seek enhanced collaboration in observing and across the value chain. This coordination will include global tracking of observing system status,
platforms for coordination of national activity at global and regional levels, the development and promotion of standards and best practices, tracking of data flow from platforms to data management systems, and the promotion of increasing readiness of new observing technologies and networks. It is also important to consider the role of indigenous communities, especially in the development of coastal observations.

Outcomes

- Increased efficiency in use of resources
- More uses of data and more users served - enhanced delivery to end users across an integrated observing system
- A system for identifying and sharing of best practices and adoption of common approaches
- Increasing the number of observing networks, sensors and platforms with a Technology Readiness Level of 7 or more
- Coordination towards achieving common goals across global, regional and national systems
- Expansion and evolution into new areas, identified through requirements and supporting emerging communities focused on solving global needs
- Increased interoperability of ocean data from variety of sources
- Support for sustainability through participation in a global integrated system

Role of GOOS (to stimulate discussion)

This is a major part of GOOS current core coordination activity. The observing system implementation components of GOOS, the Observation Coordination Group, the Regional Alliances, the BioEco Panel networks, and the National Focal Points of GOOS are all actively working on this objective. The Ocean Best Practice System a joint International Oceanographic Data and Information Exchange (IODE) - GOOS Project is developing an innovative system for the sharing of ocean best practices. GOOS Projects also support the development of future implementation components (e.g. Deep Ocean Observing System). JCOMMOPS supports the quality and flow of the metadata from the ‘global’ observing networks. There is also ongoing work with IOC, WMO, and the observing networks with regard to the work of the sustained observing networks in areas under national jurisdiction.

Potential partners (to stimulate discussion)

Partners under this objective include at a global level, WMO (both at global and national level – National Meteorological and Hydrological Services), Global Ocean Acidification Observing Network (GOA-ON), UN Environment Programme (globally and regionally). Partners and GOOS can gain in efficiency from understanding points of coordination, shared goals, and in sharing knowledge and best practice.
SO7. Ensure GOOS ocean observing data and information are findable, accessible, interoperable, and reusable\(^6\), with appropriate quality and latency

**Issue**

The ocean sustained data system architecture, from acquisition to dissemination, is incomplete and often fragmented. Some ocean data are incorporated into the WMO Information System (WIS) for coupled ocean-atmosphere forecast systems, and the IOC and ocean community are developing the concept of an Ocean Data Information System. The cultural revolution of free and open data sharing that has been achieved for most platforms measuring open ocean physical variables frequently does not extend to biogeochemical and biological variables, and to some areas under national jurisdiction. In this fragmented landscape users can find it difficult to encounter the data they need. To ensure a data system that is fit for purpose and adheres to the FAIR principals (findable, accessible, interoperable, and reusable), there needs to be a clear connection from observations to users, through relevant data management systems, that can be refined via evaluation cycles to ensure that the data is of appropriate quality and latency.

**Implementation**

Building on GOOS principles and the IOC Oceanographic Data and Information Exchange Programme (IODE) policy, we will promote that ocean observations are made available to users on a free and unrestricted basis, ensuring full and open exchange of data, metadata and products at minimum time delay, and need to be preserved and remain accessible indefinitely, wherever practical. With partners

\(^6\) FAIR principles: Wilkinson et al., 2016
we will track the performance of the global in situ observing networks in relation to these principles, through the specified data assembly centers and track availability through the use of metrics. We will engage with the observing community and data aggregators to bring these data streams together, ensuring timely data submission and mechanisms to provide credit, relevant information on data provenance and processing (metadata), interoperability between data systems (including satellite), ensuring data availability for each Essential Ocean Variables, relevant Essential Climate Variables, and all associated variables.

This is an area in which GOOS seeks strong partnership across the data management landscape. We will support the flow of data by promoting the use of modern information and communication technology, and ensuring that data and associated metadata are discoverable, however it will take partnership to reduce fragmentation and ensure data flow is increasingly frictionless. GOOS will work with partners on all levels to encourage adherence to the FAIR principles from observations to information products. Data flow will be brought into the evaluation cycle for end-to-end delivery, with an understanding of quality and latency appropriate for users, to ensure end-to-end responsiveness. The opportunity for large, sound and effective (frictionless) data flow is fundamental to delivery of a functioning system and achieving the vision and partnership is fundamental to achieving this objective.

Outcome

- More data available, more appropriately, to more users
- Availability of meaningful data metrics

Role of GOOS (to stimulate discussion)

The GOOS observing components, the Observation Coordination Group, the ‘global’ observing networks, the GOOS Regional Alliances, the BioEco Panel networks, and the GOOS Projects, all work towards FAIR data within each network and across all variables. In addition, JCOMMOPS (under the Observation Coordination Group) monitors and supports the flow and quality of metadata from the ‘global’ observing networks, JCOMMOPS also supports work towards standardization of metadata across networks, appropriate metadata is vital for achieving FAIR data principles

Potential partners (to stimulate discussion)

Oceanographic Data and Information Exchange Programme (IODE) and WMO Information System (WIS) are key global partners for data management and delivery of ocean data, and to promote FAIR principles for ocean data. National and regional ocean data centers are also key partners for data management and delivery of ocean data, and to promote FAIR (findable, accessible, interoperable, and reusable) principals for ocean data. The Global Indigenous Data Alliance (GIDA) could also be a partner in ensuring work on the CARE Principles for Indigenous Data Governance is understood.

Outcome

- An identified and tracked global observing system data architecture as part of broader oceanographic, atmospheric, and earth system data architectures
- Data products based on Essential Ocean Variables and Essential Climate Variables available in a timely manner, with appropriate quality
GOAL: BUILDING FOR THE FUTURE

Building for the future with innovation, capacity development, and evolving good governance.

The strategic objectives in Goal 3 anticipate a heightened level of cooperation between partners in the observing system enterprise, and entraining new partners beyond those involved today. Meeting these objectives will also be about co-development, GOOS can play a leading role in some, such as SO11, however it is anticipated that partners will take the lead in others.

These strategic objectives encompass areas that are beyond GOOS current core activities, but that are identified as vital to achieve the 2030 vision, GOOS will require strong partnership to fulfill these objectives, possibly with partners leading the implementation.
SO8. Support innovation in observing technologies and networks

Issue
Observing technology evolves rapidly, while a sustained observing system has to balance continuity and responsiveness to technological developments. Technological development takes place in research institutes and in commercial companies, and there is a need to connect promising developments to areas of high user need or impact. Technology also typically develops faster in more technologically advanced countries, often at a cost premium that is not affordable by less technologically advanced countries. There is an urgent need to address new sensor technology, in particular cost effective solutions to spread sustained observing.

Implementation
This is an area in which increased partnerships across the ocean research, commercial and operational communities are required to assess and improve the readiness levels and speedy deployment of promising technology, platforms and techniques, including citizen science. GOOS will capture any observing innovation outcomes from the UN Decade of Ocean Science for Sustainable Development and GOOS Projects into the sustained observing system, identify where capacity development is required for global implementation and support increased partnership for observing system technologies.

Outcomes
- Faster adoption of new technology
- Increase scope, efficiency and observational capability
- Focused and faster technological development to meet new observing challenges, including geographic equity

Role of GOOS (to stimulate discussion)
The Observation Coordination Group is undertaking some work in this area, coordinating across 'global' networks to identify technological needs.

Potential partners (to stimulate discussion)
Partners include Partnership for Observation of the Global Ocean and the affiliated research organizations active in this area, associations such as the Marine Technology Society (MTS), and commercial organizations developing technology for ocean observing. The organisers of forums for marine technology exchange are also potential partners, for example Oceanology International and marine technology hubs. Also, national and other organisations interested in supporting innovation.
SO9. Develop capacity to ensure a broader range of beneficial stakeholder participation

Issue

There are profound gaps in our ocean observing coverage. This is not a matter simply of one-off investment, but of sustained capacity development in the infrastructure and techniques of observation, the design of responsive multi-platform observing systems to meet regional and national science and societal needs, and the use of these data to deliver societal benefit. Without this pull it is difficult to conceive of sustained new observing capacity, including meeting national reporting requirements under global agreements.

Implementation

GOOS will partner in a broader context of the IOC and other Programmes to implement actions that sustainably develop capacity in ocean observations, data systems, and other elements of the value chain to deliver local benefit. Development will focus both on human capacities, as well as the transfer of marine technology, including knowledge on observing techniques and best practices. Certain contexts may require the development of observing tools and best practice guides adapted to local conditions for deployment and maintenance of observing networks, and the strengthening of local monitoring systems.

The engagement of countries that already have a strong marine science community can be achieved with modest use of new resources that link existing GOOS global and regional structures. But, in order to have any lasting impact, developing the sustained ocean observing capacity of least developed countries and small island developing states has to be done in the context of broader end-to-end initiatives that are linked to development-targeted environmental processes, like the Sustainable Development Goals, climate adaptation, the Large Marine Ecosystem programmes, or Regional Seas Conventions.

Strong and broad partnership is vital and the needs of users considered, the capacity requirements across different regions can be strikingly varied.

Outcome

• a greater number of countries actively participating in the global ocean observing system;
• a greater number of countries with capabilities in ocean forecasting
• new best practices and data products addressing the needs and capacities of increasingly diverse participating countries

Role of GOOS (to stimulate discussion)

Engagement with GOOS Regional Alliances, national ocean observing programmes, and the expert team on operational forecasting Systems (ETOOFS) particularly with regard to identifying opportunities for skills transfer and knowledge sharing. Identifying opportunities to broaden and enhance the existing capacity development through the Observation Coordination Group working with the networks and the Ocean Best Practice System (OBPS), joint GOOS-IODE project, to support training in best practices.

Potential partners (to stimulate discussion)

Partners in initiatives that are linked to sustainable development associated with the marine environment. IODE is a key partner in the delivery of training through Ocean Teacher Global Academy and through the joint GOOS-IODE Ocean Best Practice System Project. In addition, the IOC Capacity Development Working Group and Large Marine Ecosystems’ Global Environment Facility’s (GEF) International Waters Learning Exchange and Resource Network are also potential partners in this area.
**SO10. Extend systematic observations to understand human impact on the ocean**

**Issue**

A need to integrate the pressures from human activity into observation and modelling of climate and marine ecosystem health, combined with advances in observing system technology, strongly suggests that the time could be right to extend ocean observing to monitor variables and indicators of human activity and its impact on the ocean.

**Implementation**

GOOS will seek partnership to develop knowledge of the requirements landscape around human impacts and to assess elements or variables that are suitable to support as EOVs, within an integrated global observing system. It is anticipated that this partnership could identify and implement pilots to assess the viability and value of this approach, considering delivery channels from observations to end users. Possible pilots could focus on ocean sound, marine debris, and harmful algal blooms. Engagement with regional ocean assessment activities will be important to implementation and feedback on the relevance of global coordination.

**Outcomes**

- A pilot project, in partnership with other organizations in this area, around variables related to human activities, potential initial targets are ocean noise, marine plastics, and harmful algal blooms
- Recommendations for the implementation selected human activity variables within an integrated global ocean observing system, and their implementation in the EOV framework

**Role of GOOS (to stimulate discussion)**

The BioEco Panel has partnered with the International Quiet Ocean Experiment to develop an Ocean Sound Essential Ocean Variable, GOOS is also providing relevant support for the establishing global coordination of an Integrated Marine Debris Observing System (IMDOS) which would provide adequate data to inform the UN Sustainable Development Goals and other policy targets on marine pollution due to human activities.

**Potential partners (to stimulate discussion)**

IOC Programmes and the UN Environment Programme are important potential partners in this area. Other potential partners include Non-Governmental Organisations, private foundations and other initiatives that are linked to sustainable development, pollution and other human impacts on the marine environment. There is a need to develop further dialogue on how the global ocean observing system could support the measurement of needed variables.
SO11. Play a leading role in establishing effective governance for global in situ and satellite observing, together with partners and stakeholders

Issue

As the global ocean observing system grows from an initial focus on serving climate science, policy and marine services, to serve a broader suite of users across operational services and ocean health, and across open ocean and coastal applications, the complexity of the system multiplies. We operate now with a historical accretion of organizations and networks, working on different parts of the value chain from observations to end users; at a global, regional, national and local levels; and focused on different segments of users, different observing platforms, and different Essential Ocean Variables and Essential Climate Variables.

The present governance arrangements are not sufficient to realize the ambition of the 2030 Strategy, as they do not optimally connect the different communities, networks, and partners towards fully achieving their collective potential; and generally ignore private sector partnership. They do not allow for a full implementation of the concepts identified in the Framework for Ocean Observing.

An inclusive and global governance architecture is needed to enable direction setting, coordination, and enable responsiveness of the ocean observing system within this complex landscape. This architecture also needs to mesh with appropriate governance arrangements for the management of ocean-related risk, climate mitigation and adaptation, fisheries, pollution, and biodiversity issues.
Implementation

Building on engagement with stakeholders, key users, and funders, GOOS will foster a discussion with the ocean observing community on the characteristics of good governance, the potential models for governance which could set global directions and design for an integrated observing system, that can respond to global and local issues. It is important that global approaches are also inclusive of local implementation and needs for ocean observations.

Initial discussions have considered multilevel polycentric governance and collective impact organisation as potential models for such a global system of governance. Both polycentric governance and collective impact organization rely on the unifying forces of a common agenda, goals and aims. However, in the collective impact model the participating entities are coordinated by a backbone organization and establish shared metrics of success, while the polycentric polycentric systems are characterized by having overarching rules, mutual adjustment of activities (collaborate and avoid conflict), a willingness to experiment, trust among members (domains), and are supported through local action by members. The polycentric governance model is supported by regular communication, and sharing and learning processes, and have been effective in providing governance for natural resources.

The current global ocean observing system perhaps most resembles a polycentric system, in that there are multiple centers of responsibility, at different levels, national, regional and global, within networks and expert panels, and intersecting with other expert bodies around climate, biodiversity, etc. There is also currently central coordination of part of the system through GOOS, and with the 2030 Strategy a set of collective goals, encompassing a vision for a broader, more integrated and responsive global ocean observing system - in which GOOS will play an important role.

Through dialogue with partners and the observing community, we aim to develop a community consensus for an expanded governance architecture designed for the future and with ocean observing systems at the appropriate level (global, basin-scale, regional, national, and local). To identify the appropriate principles, institutions and processes of this governance system, building on existing structures wherever possible, and building on existing knowledge and practice in good governance.

Outcomes

- A governance architecture for the global ocean observing system, that integrates GOOS and partners in a framework, with clarity in roles, processes and evaluation
- A clearly articulated voice for ocean observations and services, with multiple stakeholders contributing to define the message
- Improved global observing system delivery, responsiveness and sustainability
- Greater support for national systems and their needs for ocean information

Role of GOOS (to stimulate discussion)

GOOS hosted a workshop in April 2019 to feed into a broader community discussion at OceanObs’19 on governance, work in this area will continue through discussions with sponsors and partners.

Potential partners (to stimulate discussion)

All partners and sponsors are invited to engage in the dialogue regarding effective governance for an expanded global ocean observing system. There is also ongoing action as an outcome from OceanObs’19.
5. NEXT STEPS

This *Roadmap for the Implementation of the Global Ocean Observing System 2030 Strategy* is a framework document for partners to identify and discuss their roles in achieving the vision of a ‘truly integrated global ocean observing system that delivers the essential information needed for our sustainable development, safety, wellbeing and prosperity’. We envision this document will evolve through partner and community dialogue and partners are encouraged to provide feedback on the Roadmap.

Next steps in the evolution of the 2030 Strategy and Roadmap for Implementation:

1. **Review, comment and adjustment through 2020**: Discussion with existing and potential partners about roles, targets for impact, governance and how they would like to see the Roadmap evolve. Input from the broader observing system community, including national, regional and global entities. This is a key opportunity to listen to partner and community needs and priorities. Priorities identified from the OceanObs’19 process will also be included.

2. **GOOS Implementation Plan autumn 2020**: The GOOS Steering Committee and Components will develop a 3-5 Year GOOS Implementation Plan, detailing the priorities and actions that GOOS will undertake to implement the 2030 Strategy and the work we are already undertaking with our partner organisations.

3. **Revised Roadmap in summer 2021**: With input from partners on roles, priorities and collaborative actions or activities, including greater detail on agreed targets for impact, and measures of success. Some development of the ideas on governance is also anticipated.

4. **Evolving the governance and coordinating capability from 2021**: for a truly global ocean observing system, there will need to be some agreement on the next steps towards evolving the governance. Whilst GOOS can help lead this, it needs to represent a step that will better serve global needs and the different partners in the observing system enterprise.

5. **Reporting 2023 and beyond**: GOOS will monitor achievement towards the Strategic Objectives and assess progress every 2 years. Progress towards the impact targets would also be reported.