2021 2030 United Nations Decade of Ocean Science for Sustainable Development

The Global Ocean Observing System

ObsCoDe
Ocean Observing Co-Design: evolving ocean observing for a sustainable future

Proposal for a UN Ocean Decade programme
DRAFT based on 2 March 2021 version,
for registration as a UN Ocean Decade Action by the GOOS SC via IOC/UNESCO

Abstract

Readily-available and fit-for-purpose ocean information is a foundational element in achieving the ocean we want by 2030. With integrated observation and modeling capability, we can track the current state and future variability of the ocean, enable skilful predictions and warnings, manage ocean resources, empower society to adapt to change, and ultimately, assess the impact of action towards a sustainable ocean.

Ocean Observing Co-Design aims to transform the ocean observing system assessment and design process, creating a system *co-designed* with observing, modeling, and key user stakeholders. The programme will work with existing and new observing networks, and closely couple with the modelling community across assessment, assimilation and prediction, to support the development of an integrated and agile ocean observing system with linked prediction capabilities. This fit-for-purpose observing and forecasting system will better and more efficiently serve the expanding range of societal needs for ocean information across early warning and forecasts, climate, and ocean health, it will also increase the value of this ocean knowledge to stakeholders.

Our aim is to build the process, infrastructure and tools for co-design, creating an international capacity to evolve a truly integrated ocean observing system, matching agile observing and modelling capability with requirements. By 2030 this programme will advance the maturity and robustness of the global ocean observing and forecasting enterprise, moving towards an integrated system that will increase permanent support, and provide the greatest possible impact for investment.

Ocean Observing Co-Design is an inclusive programme which aims to benefit society, where many lives and livelihoods depend on coastal and ocean resources and processes. It will provide a foundation for many of the transdisciplinary outcomes of the Ocean Decade Actions, and an opportunity for numerous partnerships, including with regional and indiginous communities, to contribute to implementing best practices of co-design for the benefit of the ocean, our climate, and society.

> *Observing System Co-Design is one of 3 linked GOOS programmes all with a focus transforming the observing system through integration, the three programmes are;* ***CoastPredict*** *- transforming the science of observing and predicting the Global Coastal Ocean, from river catchments, including urban scales, to the oceanic slope waters;* ***Observing Together*** *- supporting communities to bring needed observations and forecasts to users and into global data streams, making every observation count, and* ***ObsCoDe*** *Observing System Co-Design - creating the process, infrastructure and tools for co-design of a fit-for-purpose GOOS. The programmes are united in being transformational for the Ocean Decade and the Global Ocean Observing System 2030 Strategy. These programs intersect and it is anticipated that elements will converge towards a single integrated system by the close of the decade.*

The Big Idea

Delivering adequate information on the present and future state of the ocean is one of the most significant challenges we must address in the next decade. We need the ability to coherently integrate information across different disciplines - and across multiple time and space scales - to address the multifaceted opportunities and risks around sustainable development of the oceans. Because of the vastness of the ocean, its wide range of variability, and the multitude of processes and properties relevant to human activity, we are still far from being able to capture even the most basic set of information required for most decision making. At the same time, societal requirements for ocean information are expanding rapidly, with users in different economic sectors, requiring information at different scales, quality and latency.

In response to science and societal demand, numerous communities have developed global-scale observing plans, programs and observing networks, however much of the resulting data are generally taken in isolation, and are assessed through the lens of individual programs and networks. A future of many individual observing systems tailored towards the specific needs of a growing range of ocean knowledge consumers is clearly unsustainable and costly. The present paradigm of disparate ocean observing efforts, inconsistent observing, and gaps in the value chain that inhibit data delivery and feedback on fit-for-purpose, is not providing a robust and integrated observing and forecasting system, which consistently provides for informed decision-making and skillful earth-system prediction.

Through co-design principles this programme will develop an integrated approach that explicitly links observing systems to modelers, service and information providers. It will develop the process and infrastructure to provide a common source of information and tools to support decision making for the design and implementation of a fit-for-purpose ocean observing system, with a modular and scalable approach that can be applied at global, regional and local levels.

The programme will provide the collaborative structure to drive, support and review a robust, scalable and open observing system design, support greater efficiency in investment decisions, and enable regular reporting on progress towards addressing identified societal service targets. The programme will communicate on impact via a series of metrics, dashboards, and reports to evaluate its performance towards delivering to a broad range of user needs. Such metrics can interleave across the system addressing global, regional, or local needs, and the impact of the data on policy, governance, and public arenas.

At the global level, countries have made collective commitments to address climate action through the UN Framework Convention on Climate Change (UNFCCC) and the Paris Agreement, to address biodiversity through the Convention on Biological Diversity (CBD), to reduce the risk of disasters through the Sendai Framework, and to take action for sustainable development through Agenda 2030 and the Sustainable Development Goals (SDGs). Each of these global frameworks puts individual responsibility on countries to monitor and report on progress, and each therefore needs a supporting system of ocean observations, data, and analysis and modeling activities. This programme will diagnose the ability of ocean observations and forecasting systems to deliver for these global frameworks through exemplars, as well as provide the infrastructure to test the system for regional and local needs. Gaps in ability will help prioritize future development.

New technology innovation in areas such as Big Data, Artificial Intelligence and Machine Learning are now entering into all areas of ocean observing, from automated observing component deployment, to quality control and initiatives to simulate scenarios within digital representations of the ocean. As these technologies become more mainstream, in the future both human and machine interplay with digital representations of the ocean may inform requirements of the observing system. The Programme will develop connections with forward looking projects such as these within the Ocean Decade, and beyond, to benefit from insight into how these technology developments will influence data use and system design.

Delivering to expanding user and societal requirements necessitates an increasingly integrated approach across fit-for-purpose observing systems, modelers, and information providers, to ensure the utility of the ocean knowledge delivered. An integrated and co-design approach described in this programme will offer new opportunities for these stakeholders across GOOS to build consensus-building approaches, core capabilities, and decision-making targeting observing system design, system evolution, evaluation improvements of the system, and prioritisation of investments. These capabilities are not only necessary, they are critical, to ensure efficient future development of the system as information needs expand; demonstrating the return on investment of a sustained and responsive global ocean observing system, and a more widely shared understanding of its value towards sustainable development of communities around the world.

High level objectives

1. Integrate observing and modeling to measurably better support a sustainable ocean and society
2. Make ocean observing and information appreciably more impactful through transformative co-design with the modelling community and key user stakeholders
3. Establish the international capacity and modular infrastructure to co-design and regularly evaluate the observing system
4. Entrain new observing and information technology across all elements of the programme.

(defining 1) **Co-design** combines the knowledge of multiple experts and stakeholders, helping to create innovative concepts and ideas that meet the needs of these stakeholders, and that could not have been produced by any one of those involved working alone. Here co-design is understood as a continuous process, a collaborative and iterative effort among all stakeholders. It will be undertaken at multiple levels, across the programme. At any level, co-design includes jointly designing work and coordinating actions as a team of designers, developers and users to ensure the final result is achieved and that it is fit for purpose.

(defining 2) **Fit-for-purpose** is the simple concept by which a product, service or infrastructure is adequate for the purpose for which the user selected it. Appropriate, and of a necessary standard, for its intended use, in fact European law dictates that goods must be fit for purpose when sold. Creators of products and services need a system for understanding their customers.

(defining 3) An **integrated** ocean observing system operates from the open ocean to the coast, across physical, chemical and biological realms, includes initiatives at local, national, regional and global levels, connects observations to data management, modelling, assessments and other providers of information and services to end-users, and serves the needs of users across climate, hazard warnings, forecasts, and ocean health.

(defining 4) key user **stakeholders** will be the organisations providing services to user areas identified in the exemplars, many of the initial stakeholders are identified among the partners of the programme. Thereafter, as the programme develops, new stakeholders will be identified beyond the initial partners and advisory group members.

Why Now?

The Global Ocean Observing System (GOOS), with its partners, is continuously developing and advancing an integrated ocean observing system using the Framework for Ocean Observing[1] (FOO), and most recently the Global Ocean Observing System 2030 Strategy[2], where the need for regular cycles of evaluation has been identified.

Currently this is approached in different ways and for different foci, for example through scientific reviews, assessments against Global Climate Observing System (GCOS) targets, and the WMO Rolling Review of Requirements for marine meteorological measurements. Yet, there remains little synthesised guidance and a lack of established best practice to evaluate the observing system against an integrated set of objectives, as a whole, or at regional and local levels, or against the needs of an increasingly broad range of ocean data users, and for activities that have the potential to contribute to GOOS but are not yet integrated.

Successful regional examples that have applied the FOO to evaluate a basin scale system are the Tropical Pacific Observing System (TPOS) Project, the Tropical Atlantic Observing System (TAOS) consortium and the Indian Ocean Observing System (IndOOS) consortium. However despite this progress, significantly more integration, between open-ocean and coastal observing, between scientific disciplines, between operational and research institutions, and crucially down the value chain to more clearly address societal needs for improved ocean knowledge, is needed.

GOOS and a strong consortium of partners, including modelling and user stakeholders, are poised to embrace this integration challenge and are uniquely positioned to build on existing infrastructure and projects to address this system-wide integration challenge. We can only undertake this significant challenge with a dedicated, decade-long effort, strong partnership, the development of new co-design processes, an evolution in system governance, and targeted resourcing.

Programme Legacy

The programme aims to build the process, infrastructure, and tools for co-design, creating an international capacity to evolve a truly integrated ocean observing system, matching agile observing and modelling capability with requirements. Through strong partnership it will provide a collaborative structure to create, support, and test a scalable and modular assessment framework and processes. This will be developed and integrated with the observing and modelling community, and will enable regular reporting on progress towards addressing identified use area targets. The framework will be scalable to enable assessment at global and regional scales, and across existing and new ocean observing infrastructure and plans. We will need this to support efficiency in investment decisions and to enable adjustment of the global and regional observing systems to meet changing needs and new technology.

[1]Task Team for the Integrated Framework for Sustained Ocean Observing (2012) A Framework for Ocean Observing. Paris France, UNESCO, 25pp. (IOC Information Document 1284, Rev. 2). DOI: 10.5270/OceanObs09-FOO

[2] www.goosocean.org/2030Strategy

Through partnership and the process development this programme will advance the maturity and robustness of the observing system governance.

The ocean observing and modelling community will grow and become more inclusive to address needed capacity in designing, evaluating, and improving the global ocean observing system on a range of scales from global to regional/local. Regional and indigenous and other communities of practice will have more opportunities to become Programme partners, providing the knowledge and capacity to support observations especially in more remote areas. A Programme priority will be to encourage involvement of smaller and indigenous communities and their representatives to ensure that the co-design results reflect their needs, contributions, and expertise and they are able to benefit from the Programme's activities.

Anticipated Outcomes

1. Responsive and efficient delivery of ocean data to societal needs through testing the observing system against 'exemplars' - examples of end user need areas - and providing the data needed for new digital ocean simulation services, supporting stakeholder and public access to new digital representations of the marine environment.
2. A dynamic fit-for-purpose observing and prediction system to ensure rapid responsiveness to evolving needs and technologies, reflecting multiple mission needs and spatial scales.
3. An open and transparent observing requirements synthesis and assessment process, to ensure the global ocean observing system reflects a multiple and diverse set of stakeholder needs and priorities.
4. Reports, diagnostics and authoritative assessment of the ocean observing system to support the identification of prioritized gaps
5. An integrated observing-model community/system for co-design of ocean observing and forecasting, to improve model exploitation of ocean observations, and to advance forecast system capabilities for the benefit of downstream users.
6. Improved engagement with observing system sponsors seeking maximum return on new ocean observing system investments, and to sustain existing essential elements.
7. Enhanced and rapid integration of new observing system components into the global ocean observing system framework.
8. A leading edge sustained observing infrastructure using targeted projects and new technologies to fill identified observing gaps.
9. A sustained and modular infrastructure, process, and tools to guide and support implementation decisions at global, regional and national level.
10. Creation of a new and inclusive workforce capacity dedicated towards the design, implementation, evaluation, and evolution of the global ocean observing system.

Programme Implementation

The stakeholders will initially encompass many of the programme partners to support understanding and synthesis of requirements and observing and forecasting system co-design for the major areas of action

Key to implementation of this programme is a broad partnership with the modelling community, the observing community and user stakeholders. The programme will assess fit-for-purpose

through the use of observing system ‘exemplars’ - examples of end user need areas - to drive a process for synthesis of requirements, analysis of system capability and reporting. The process, infrastructure and tools for co-design will be created through building on existing infrastructure, such OceanOPS and OBIS, plus links to other transforming initiatives such as ForeSea (OceanPredict), CoastPredict, Marine Life 2030, Digital Twin of the Ocean (DITTO) and others, through projects. The Advisory Group, with many user stakeholders, will develop the ideas for initial exemplars, based on inputs from key stakeholders and observing system readiness

Implementation Concepts

The programme implementation is based around three core concepts; assessment through deeply understanding the observing requirements needed to address specific problems - the exemplars concept; co-design with modelling community and key stakeholders/partners; and finally evolution and innovation in the observing system, the concept that we will work with existing networks, forward plans and integrate new elements, including working with and co-developing with sister Decade Programmes on parallel pathways.

1. Exemplars

The use of observing system ‘exemplars’ (examples of end user need areas) will drive requirements analysis, gap analysis and observing system design recommendations. Using these we will build up processes, infrastructure, analytics, testing, reporting and guidance, prioritisation and best practices. An early action of the Advisory Group (see governance section) will be to assess and develop the ideas for initial exemplars, based on inputs from key stakeholders and observing system readiness.

Some initial and non-definitive ideas for exemplars are provided below, across areas of climate, prediction, hazard warning, and ocean health:

- Improve operational ocean forecasting from the global to the regional and coastal scales
- Forecasting and projecting climate extremes in seamless prediction systems
- Storm surge and tsunami early warning as important areas of service delivery
- Measurement of ocean ecosystems and their services at a local level for natural capital accounting, for both policy and business decision-making purposes
- Monitoring and predicting the ocean component of the global energy, water, and carbon budgets/cycles, through indicators
- Supporting governments in implementing, monitoring progress toward and reporting on commitments to multilateral environmental agreements (MEAs), including delivery against the ocean-related indicators of the emerging post-2020 global biodiversity framework
- Businesses and financial institutions supported for investment in nature positive contributions (e.g. marine and coastal ecosystem restoration and blue carbon)
- Improving the key information that supports the reinsurance industry in creating products (i.e., coastal risk, blue carbon resilience), and responding to changing risk (i.e., mapping vulnerability to climate and ocean hazards);

2. Co-design partners and process

The co-design process will work on understanding and co-defining synthesised requirements for the exemplar user case areas. In parallel, objective procedures will be implemented for qualifying the best approaches in terms of cost versus benefits, for integrated observing components. Such procedures will include the use of models to develop the architecture and estimate the impact of observing system options by means of Observing System Experiments (OSE) in which existing observations are withheld from assimilation into models and then the magnitude of the degradation in predictions is observed, and Observing System Simulation Experiments (OSSE) using models to simulate observations that would be produced by new/modified observing systems and to estimate the impact of those observations on predictions or other requirements. These procedures will allow regular evaluations and will take into consideration new requirements, both evolving observing technology and also the evolution of modelling (and data assimilation) capabilities. New analyses based on Artificial Intelligence methods will further enhance the ability to objectively define the most appropriate observing systems that will fit with the requirements. We will work closely with sister Ocean Decade programmes ForSea, CoastPredict and Digital Twins of the Ocean (DITTO) and envision interlinked co-development projects with these important co-design partners.

3. Observing system evolution and innovation

To deliver an integrated ocean observing system, it will be important to work with existing and new observing elements, in order to assess current observing system status and planned innovations, and to enable forward looking gap analysis and efficient design considerations. The programme will also have a focus on integrating observing ideas, platforms and ocean scales, and design elements that are developing within key Ocean Decade Programmes.

To support the aims of this programme, and the Ocean Decade, enhanced and rapid integration of new observing system components into the global ocean observing system framework will be required.

Implementation Phases

We envision 3 implementation phases for the Programme, reflecting the readiness and interests of the community during the early stages, and in the later phases focusing on gap filling and long-term and less-mature capabilities. Brief outlines are provided below with more detail in Annex 1.

Phase 1 (short term 1–3 years): The initial integration focus will be on the open and coastal ocean, and physical, and biogeochemical variables, with some emphasis also on select biological EOVs. Early consultations with key stakeholders will set priorities, define projects and co-design processes.

Phase 1 will develop through a series of exemplar focused projects the infrastructure and capabilities to monitor and report against ocean information use areas. Another key component in phase 1 will be to work with existing observing systems and networks on future plans and with new observing projects under the Ocean Decade, in order to enable forward projection of observing capacity for analysis and to support new observing components in delivering into the global system and to global requirements. At the end of Phase 1 we anticipate having developed process and initial tools to test, visualise and report on the status of the observing system to meet users needs across the first exemplars in climate and

operational services areas. An initial authoritative and objective diagnostic on ocean observing status, gaps, and design provided across a first group of requirements could be a major output. Foundational projects addressing less mature areas such as coastal ocean and biological, ecological and human pressure variables will be initiated to prepare for later programme phases. The learning in this first phase will lead to the development of process, best practices, and with OceanOPS and partners in the modeling community, tools for testing and analytic capability. This will deliver an initial and innovative base for the design and development of more permanent and scalable infrastructure - developed in phase 2. Connections with new digital technologies for artificial intelligence and digital twins of the ocean will be deepened to enable new technology evolution to be incorporated into the designs moving forward.

Phase 2 (mid term 4–6 years): During this phase, we will expand the scope of the system assessment and status capabilities to address exemplars in the areas of biology, coasts and human pressures. We will initiate new observing system projects to fill co-design identified priority gaps for the second half of the Decade, and build on earlier successes with integrative work across networks. Consolidating earlier project success in this phase we aim to plan and then build key infrastructure capabilities to support observing system monitoring and reporting at a range of scales. The output of this would be an open collaborative infrastructure, tools, and processes to drive, support and review a robust, scalable and open observing system design framework. Parts of the process may be undertaken by partners, be additional to existing facilities or be new, it is also intended the architecture would be modular to enable assessment at a range of scales, national, regional, global, and for a range of exemplars. This will include recommendations for best practice in process and, if required, some recommendations for governance of a co-design process. We also aim to incentivize communities, including indigenous communities, to join the ocean observing work force, e.g. create a new career path, growth in the number of available jobs.

Phase 3 (long term 7 – 10 years): The elements for this phase are more open, as this will be guided by the programme development in the preceding 6 years, and with a view to leaving a sustained legacy from the programme. They will include finalising the authoritative reports on ocean observing status, gaps, and design with a focus on the fully integrated system and potentially including 10 to 30 year outlooks, the merging of modelling and observing systems for integrated delivery assessment, a key high level objective of the programme, will be finalised, based on work in the 2 preceding phases, plus connections to new digital technology services or capability. An independent programme review will inform the next decade of development.

Partners

Advisory Group & Co-Design Partners

OceanPredict
Fraser Davidson - Fisheries and Oceans Canada
Elisabeth Remy - Mercator Ocean International, France
Yosuke Fujii - Japan Meteorological Agency, Japan
A key partner for co-design, with specific co-projects that we work on together, for example OSSEs. Work closely with the “ForSea” Decade Programme and the task team SynObs.

World Meteorological Organisation (WMO)
Anthony Rea - WMO INFCOM, Switzerland
WMO are supportive of all the high level objectives, in particular with regard to requirements for weather forecasts and extremes, observing/modelling co-design projects.

World Climate Research Programme (WCRP)
Lisa Beal (CLIVAR SSG), US
The programme will support the development of a framework for assessing and explaining regional climate risk to deliver climate information that is meaningful at the local scale, and in developing Digital Earth's blend models.

European Centre for Medium Range Weather Forecasts (ECMWF)
Magdalena Alonso Balmaseda - ECMWF, UK
ECMWF have powerful capabilities for data assimilation of the individual earth system components (atmosphere, ocean, sea-ice, land and waves), and are developing coupled data assimilation systems. ECMWF has interest in, and can help with the assessment of the ocean observing system.

Copernicus Climate Change Service (C3S)
Samantha Burgess - Copernicus Climate Change Service, UK
C3S are delighted to support this initiative and will discuss how C3S can engage in this initiative further, one area could be in engaging through a climate focused exemplars.

International Oceanographic Data and Information Exchange (IODE)
Taco de Bruin - IODE, Belgium
Ward Appeltans - Ocean Biodiversity Information System (OBIS), IODE, Belgium
IODE has vast capabilities and experience in the exchange of oceanographic data and information across agencies worldwide. They will be crucial in informing and guiding this programme in terms of data needs of end users and products and determining any data requirements exemplars.

Mercator Ocean International (MOi)
Pierre Yves le Traon, Mercator Ocean International, France
Mercator Ocean International and CMEMS are keen to be engaged in this programme and like very much the idea of co-design of the observing system**.** MOi is involved in many OSE/OSSE activities to support the design of in-situ and satellite observing systems. In addition MOi also leads the development of Digital Twin Ocean activities in Europe and contributes to the DITTO decade programme proposal.

Copernicus Marine Service (CMEMS)
Pierre Yves le Traon, Mercator Ocean International, France

Pierre Bahurel, Copernicus Marine Service, France
CMEMS provides regular and systematic reference information on the physical (blue) and biogeochemical (green) ocean and sea-ice (white) state for the global ocean and the European regional seas. More than thirty thousands of expert services and users worldwide are now registered to the service. Collaborating on exemplars could be an important area of cooperation.

Global Climate Observing System (GCOS)
Han Dolman, Netherlands
Engagement in co-design for climate exemplars across domains in an Earth System approach; for example the energy, water, and carbon cycles - testing if the programme's approach can be used across domains and sharing best practice from others.

Marine Biodiversity Observation Network (MBON)
Frank Muller-Karger, Institute for Marine Remote Sensing/IMaRS, US
Emmet Duffy, Smithsonian Environmental Research Center, US
Would like to help integrate Marine Life 2030 as an integral part of the co-design of GOOS, and MBON is a willing partner in the process of building community.

UN Environment Programme World Conservation Monitoring Centre (UNEP-WCMC)
Lauren V. Weatherdon - UNEP-WCMC, UK
Important deliverer of synthesized ocean information to multilateral environmental agreements with significant opportunities for collaborative data (metadata) curation and processing, and support alignment with the Marine Life 2030.

IOC-UNESCO Marine Policy and Regional Coordination - ICAM / MSPglobal / Blue Economy community
Alejandro Iglesias Campos - IOC-UNESCO Marine Policy and Regional Coordination Section, France
Julian Barbiere - IOC-UNESCO Marine Policy and Regional Coordination Section, France
Support the co-design of actions to extend systematic observations to help understand the impacts of human activities on the ocean and in support of national, regional and transboundary policy development. The ICAM Strategy (including MSP, Blue economy and LMEs) can contribute to the co-design and also be considered as a user. The new MSP roadmap (2022 - 2027) will include a priority action for the promotion of ocean observations in support of policy development in line with the EU Green Deal, SDGs and the Ocean Decade.

Integrated Marine Observing System (IMOS)
Michelle Heupel - IMOS, Australia
Insight on assessing across science and societal needs, multi-platform observing system integration and delivery of services.

Balearic Islands Coastal Observing and Forecasting System (SOCIB)
Joaquín Tintoré - SOCIB, Spain
Insight on assessing across science and societal needs, multi-platform observing system integration and delivery of services.

Integrated Ocean Observing System (IOOS)
Carl Goldman - NOAA, USA
Insight on assessing across science and societal needs, multi-platform observing system integration and delivery of services.

Partner Ocean Decade Programmes

CoastPredict
Nadia Pinardi, University of Bologna, Italy
Villy Kourafalou, University of Miami, US
Joaquín Tintoré, SOCIB, Spain
Working closely in requirements and setting exemplars in line with Decade aims, especially the “predicted global coastal ocean”, providing the coordination with the open ocean networks, the satellite observing, co-designing the standards for multidisciplinary observing in the coastal areas and fostering the early engagement of the advanced coastal observing community (robotics).

Marine Life 2030
Frank Muller-Karger, Institute for Marine Remote Sensing/IMaRS, US
Working closely in requirements and setting exemplars in line with Decade aims, building on joint efforts between MBON, GOOS, OBIS, the Ocean Best Practices System, and other water-related elements of the UN, Group on Earth Observations (GEO), Non-Governmental Organizations, and coastal communities in greatest need of help.

Biomolecular Ocean Observing Network (BOON)
Margaret Leinen, Scripps University, US
Biomolecular observations will provide important additions to all biological EOVs, and are an important future component of an integrated ocean observing system.

ForeSea
Fraser Davidson - Fisheries and Oceans, Canada
Yosuke Fujii - Japan Meteorological Agency, Japan
It is anticipated that this OceanPredict Decade Programme will contain common project elements with Ocean Observing Co-Design. Obs/Modeling objectives will be mainly achieved through a collaboration between ForeSea, Ocean Observing Co-Design and CoastPredict through a common comprehensive project - Synergistic Observing Networks for Impactful and Relevant Ocean Predictions (SynObs). SynObs could develop to include several projects focused on the identified exemplars.

DITTO: The DIgiTal Twins of the Ocean
Martin Visbeck, GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany
Digital Twin technology will enable users to explore and understand the consequences of specific interventions or solutions. It will provide a learning, simulation and optimisation environment for interventions without endangering the real ocean. These technologies allow users to define and refine good solutions and through a range of information delivery options, including immersive visualisations, provide virtual reality views of past, current and future ocean states taking into account different ‘what if’ scenarios. This has the potential to provide new types of information on observational needs.

Observing Air-Sea Interactions Strategy (OASIS)
Meghan Cronin - NOAA/PMEL, US

Working in both setting requirements for exemplars towards improving observations, knowledge, and information of physical and biogeochemical processes that couple the oceanic and atmospheric boundary layers, affecting marine weather, climate variability, uptake of carbon dioxide, and the ocean health, including the marine ecosystem and biodiversity beneath the surface of the ocean. And in integration with other observing networks in a multi-platform integrated system.

OneArgo
Megan Scanderbeg, Deputy Director of the Argo Program, US
OneArgo will transform the revolutionary 'core' Argo array to one that has truly global reach . Through Argo's novel data management system, all data will be freely shared in real-time with a very high quality version . Implementing OneArgo will impact ocean and climate services, predictions and research, and enable groundbreaking developments in understanding ocean ecosystems, forecasting ocean productivity and constraining the global carbon and energy budgets. Collaboration with this programme will inform the development of exemplars and inform overall co-design structure.

Programme Management Structure

The Programme will be led by Co-Chairs from the GOOS Steering Committee.

Programme Advisory Group, drawn from a range of stakeholders and partners, representatives of the GOOS elements, and additional experts as required, will provide both strategic and technical advice; recommend and monitor progress towards stated metrics and objectives; ensure stakeholders and expertise are engaged; and provide regular guidance and feedback to an Action Team

Industry Stakeholders Group: a group of industry stakeholders (both technology providers and end users) will meet once a year, to assess programme progress and provide feedback on evolution and objectives. Although it will be difficult to capture all of 'industry' in one group, it is relevant to have some representation of a commercial sector view.

Programme Management Group, will comprise the leads of key implementation partners, the leads of the GOOS elements and a project manager/lead. This group will meet more frequently and will be the main coordination unit, to enable cross-GOOS and cross-partner planning of the initiatives. The Programme Management Group will report to the GOOS Steering Committee, which will provide top-level strategic feedback, ensure continuity, and approve the Programme Plan. The Programme Management Group will also integrate guidance from the Programme Advisory and Industry Stakeholders Groups.

Programme Action Team. The programme will rely on a team of individuals who will, as part of the newly sponsored activities, carry out the many tasks outlined in this proposal, both within GOOS existing components and with partners through linked projects and infrastructure. Led by the project manager/lead, the action team will comprise of the people working on components of the Decade implementation within GOOS and partners and will be part of the GOOS Office. The action team would be responsible for core programme implementation and coordination for delivery of project elements.

Budget

An estimated total budget would include the total cost of all potential projects that could, in a decade, be a part of this proposal and is therefore subject to large uncertainty. An order of magnitude estimate for a successful and a reasonable project is suggested here as a scale. The proposed budget is not reconciled with projected costs from partner Programmes and Projects.

There are three components to the total budget:

1. Core programme infrastructure needs, programme management, project and partner management, core infrastructure, tools and process (see Annex 3)
2. Project/co-project needs to develop tools/process (15 projects - exemplars and for developing model (OSSEs) analysis and/or developing infrastructure - $1-2M each)
3. Observing and modelling system 'gap' filling projects , based on gaps related to findings of the programme (15 x $10M - considering that any observing project has to have adequate data/metadata funding included).

Summary: $25M for 10 years of programme support, core infrastructure, analysis and reporting, plus $30M for projects developing processes and modular tools, and $150M for large scale projects targeting priority observing and modeling gaps. **Programme Total: $205M**