Article for the Institution of Environmental Sciences (UK) by Emma Heslop

GOOS and the Ocean Decade – fit-for-purpose ocean observing as a foundational step towards success

The UN Decade of Ocean Science for Sustainable Development (Ocean Decade) is a major opportunity for society to halt long term decline in the marine environment and to ensure that future ocean decisions are based on solid foundations. It has the full backing of the United Nations, and will be highlighted this year through the UK's G7 presidency and hosting of COP26. Attaining a **fit-for-purpose ocean observing and forecasting system will be a fundamental step towards success** in the Ocean Decade, we cannot make sound decisions without information, and cannot manage what we cannot measure.

Long term ocean observations allow us to better understand climate change and variability, and improve our forecasting of climate, weather, ocean status, and environmental hazards and their impacts. Achieving sustainability at global, regional and local scales will require a comprehensive understanding of the current and projected state of our ocean, seas and coasts, across interlinked physical, biogeochemical and biological realms. Ocean information provides an evidence base for real-time decision-making, tracking the effectiveness of management actions, and guiding adaptive responses on the pathway to sustainable development. Enhancing our ability to provide relevant information is vital to addressing societal needs, building resilience and climate adaptation strategies, as well as being the foundation for sustained and vibrant marine ecosystems. Ocean knowledge and information also have the power to generate jobs and profits in a sustainable marine economy. By 2030, the ocean economy is predicted to be a much larger component of many national economies[1].

Today, observations provide the backbone for ocean and weather forecasts, deliver understanding of the ocean's role in the global climate system, as well as the climate's impact on the ocean. However, it is clear that to meet the growing demands of policy makers, private sector users and the general public, we need a step change in the breadth and extent of the ocean observing system.

The Decade outcomes of a healthy and resilient ocean, a productive ocean, a predicted ocean, a safe ocean, and a clean ocean will all rely on fit-for-purpose observations flowing from an integrated observing system connected to prediction, assessment, science, and information services, in order to deliver information to those who will need it in a timely manner. The Ocean Decade is delivering the opportunity for the ocean community to take a long view and think big about what is needed, and with a decade perspective we can achieve this transformation, starting with the foundational steps.

The need for expansion of a global ocean observing system, designed to meet the requirements of a broad suite of users, is clear and urgent and was outlined in the Global Ocean Observing System 2030 Strategy[2], which identified a vision for a truly integrated global ocean observing system that delivers

[1] OECD publication, The Ocean Economy in 2030

[2] The Global Ocean Observing System 2030 Strategy. IOC, Paris, 2019, IOC Brochure 2019-5 (IOC/BRO/2019/5 rev.) - www.goosocean.org/2030Strategy

the essential information needed for our sustainable development, safety, wellbeing and prosperity. It also identified that GOOS cannot achieve this vision alone, and that it will take partnership to grow an integrated, responsive and sustained observing system.

The Global Ocean Observing System (GOOS) took up the transformational challenge of the Decade and identified 3 key areas for action, where bridging gaps will have a significant impact on the Ocean Decade outcomes: connecting the open ocean to the coast, integrated system design, and connection from observing through to communities. With strong partnership three linked GOOS Ocean Decade programmes, all with a focus on transforming the observing system through integration, have been developed:

- **Ocean Observing Co-Design** (ObsCoDe) - creating the process, infrastructure and tools for the co-design of a fit-for-purpose GOOS.
- **CoastPredict** - will transform the science of observing and predicting the Global Coastal Ocean, from river catchments, including urban scales, to the oceanic slope waters, and;
- **Observing Together** - supporting communities to bring needed observations and forecasts to users and into global data streams, making every observation count;

The programmes are united in being transformational for the Ocean Decade and the Global Ocean Observing System 2030 Strategy. These programmes intersect and it is anticipated that elements will converge to 'one' integrated system by the close of the decade.
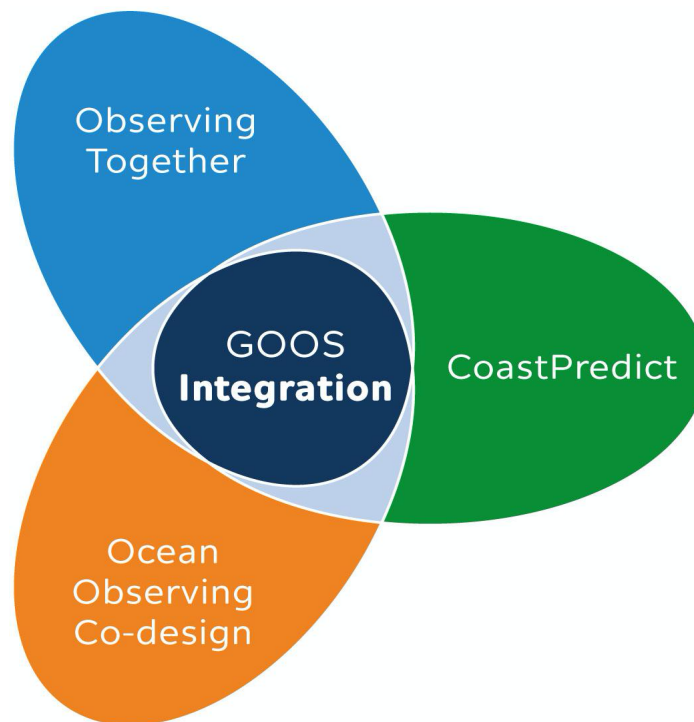

Figure 1: The 3 GOOS Programmes are focused around the core theme of integration – integration down the value chain to users, with the modelling community, from open ocean to coast, across the physical, biogeochemical and biological realms, and integrating as many nations and communities into the global system as possible.

We cannot achieve the ambition of the Ocean Decade with a business-as-usual approach and here the Decade is, again, having a beneficial effect. It has been a stimulation for a kind of 'speed dating' across organisations and programmes, creating new connections and partnerships that have strong potential for progress towards an integrated system.

The GOOS Decade Programmes

Ocean Observing Co-Design (ObsCoDe) aims to transform the ocean observing system assessment and design process, creating a system co-designed with observing, modelling, 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. Readily-available and fit-for-purpose ocean information is a foundational element in achieving the ocean we want by 2030. Through integrated observation and modelling 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. 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. 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 raise permanent support and increase the impact of investment.

Key to this is broad partnership with the modelling community, the observing community, and user stakeholders. The programme will assess fitness-for-purpose through the use of observing system 'exemplars' - examples of end user need areas - to drive synthesis of requirements, and diagnostics on observing system status. The process, infrastructure, and tools for co-design will be created through building on existing infrastructure and developing innovation through projects and partnership, for example with other Decade initiatives; ForeSea, which will contain common project elements with Ocean Observing Co-Design, CoastPredict, Marine Life 2030, and the Digital Twins of the Ocean (DITTO).

CoastPredict[3] will transform the science of observing and predicting the Global Coastal Ocean, from river catchments, including urban scales, to the oceanic slope waters. It will integrate observations with numerical models to improve prediction, with uncertainties, from extreme events to climate, for coastal marine ecosystems, and for biodiversity; co-designing a transformative response to science and societal needs in the coastal zone.

CoastPredict will re-define the concept of the Global Coastal Ocean, focusing on the many common worldwide features, to produce observations and predictions of natural variability and human-induced changes in the coastal areas and upgrade the infrastructure for exchange of data with standard protocols. By the end of the decade observations and modelling will be integrated in the coastal ocean. The programme anticipates projects across key societal impact areas and will require new observing as well as new modelling technology to be developed.

Observing Together aims to transform ocean data access and availability by connecting ocean observers and the communities they serve, through enhanced support to both new and existing community-scale projects. Globally, many communities are unable to access ocean data in decision-ready formats and so cannot see the value of investment in ocean observations. Co-design will broaden equitable access to and relevant application of ocean knowledge by a myriad of stakeholders.

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[3] https://www.coastpredict.org/

It will leverage the Global Ocean Observing System's network of expertise to bring needed observations and forecasts to community users and into global data streams, making every observation count.

This multi-year programme will provide a platform for connecting inter-disciplinary projects under the Ocean Decade that seek a deeper understanding of regional ocean issues and will build partnerships across the value chain - from observing networks through data and forecasting systems, scientific analysis and assessments, to service providers and users. The programme will assist ocean observers to work within the GOOS Framework for Ocean Observing (FOO) and enable the observations to be integrated into end-products designed to meet specific stakeholder needs. GOOS expertise, resources, partnerships, and networks will be applied to deepen engagement throughout the ocean data ecosystem to advance the application and impact of observations, and to demonstrate benefits and increase return on investment. By assisting such efforts to enhance their practices and contribute to the GOOS, there will be considerable added value to the projects, the Ocean Decade, and the global stakeholder community.

High Level Objectives of the 3 GOOS Programmes

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

CoastPredict
- A predicted global coastal ocean.
- The upgrade to a fit-for-purpose oceanographic information infrastructure.
- Co-design and implementation of an integrated coastal ocean observing and forecasting system adhering to best practices and standards, designed as a global framework and implemented locally.

Observing Together
- Equitable and practical access to ocean observations enabled by engagement and co-design with local observation and stakeholder communities.
- A truly Global Ocean Observing System that makes a greater number of global and local observations available, integrated, interoperable and comparable.
- Strengthened connections, mutual understanding, and improved knowledge sharing between ocean observers and the stakeholder communities they serve, at the global and local scale.
- Increased evidence that ocean observations are applied to solve problems and inform decision-making at community, national, regional, and global levels.
- Efficient design and use of ocean observations to maximise return on investment.

A growing cluster of Ocean Observing Actions

There are also many exciting actions dedicated to supporting the closing of specific gaps in our ocean observing and forecasting system coming up from within the observing community, such as; Marine Life 2030, focused around biological monitoring; Observing Air-Sea Interactions Strategy (OASIS), focused around improving air-sea flux monitoring; Biomolecular Ocean Observing Network (BOON), focused around genetic monitoring; Odyssey, focused around enabling new observing contributors

from recreational or working users of the ocean; Deep Ocean Observing Strategy (DOOS), focused around deep sea observing; OceanPractices, supporting ocean stakeholders in sharing, and collectively advancing ocean methodologies across the value chain; OneArgo, focused on expanding biogeochemistry, deep monitoring and high latitude Argo monitoring; MegaMove, focused on using animal tracks and behaviour for spatial management and conservation; and GO-SHIP Evolve, focused on developing GO-SHIP biological and ecosystem monitoring, plus enabling more nations to participate.

In addition, there are actions beyond observations that will also have strong links to the GOOS programmes, including ForeSea, where modelling and observational objectives are supported through collaboration between ForeSea, Ocean Observing Co-Design, and CoastPredict, and the Digital Twins of the Ocean (DITTO), which will enable users to explore and understand the consequences of specific interventions within a digital ocean.

This is just to mention a few. The first call for actions in the Ocean Decade has received over 200 submissions, a significant proportion of which have been identified as related to ocean observing. This perhaps indicates the foundational role of observations in meeting the Ocean Decade challenges.

Galvanising for the Decade

There has already been a positive impact from the Ocean Decade in galvanising the community to look at long term goals and form the partnerships that will be needed to reach them. This year will see the Ocean Decade meeting its first real test as these programmes will begin to seek investment. The base for this investment has the potential to be broad -- encompassing philanthropy, governments, NGOs, and industry. With the establishment of National Decade Committees, there are promising signs that the UK and other nations are taking the challenge of the Ocean Decade seriously, and understand that strategic investment now, across Ocean Decade actions, can have a major impact on human and ocean wellbeing.

We cannot pretend that the outcomes for the ocean and society are disconnected. The Ocean Decade offers a wealth of initiatives for long term beneficial change, and careful investment will reap big rewards for society.

Contact point: **decade@goosocean.org**

Dr Emma Heslop
Programme Specialist for the Global Ocean Observing System (GOOS)
Intergovernmental Oceanographic Commission (IOC) of UNESCO.
Emma is a physical oceanographer with significant strategic & business development expertise. She has a focus on energising the GOOS community, nations and partners towards the implementation of this ambitious Global Ocean Observing System 2030 Strategy. The oceans play a key role in our sustainable future and ocean observations are the foundation to achieving this.

About GOOS

Since 1991, we have been leading the development of a truly global ocean observing system that delivers the essential information needed for our sustainable development, safety, wellbeing and prosperity.

GOOS is led by the Intergovernmental Oceanographic Commission (IOC) of UNESCO, and co-sponsored by the World Meteorological Organization (WMO), the United Nations Environment Programme (UNEP) and the International Science Council (ISC).

We lead and support a community of international, regional and national ocean observing programmes, governments, UN agencies, research organizations and individual scientists.
There are seven elements to the GOOS core team.

- **GOOS Steering Committee**; a multinational body that provides direction to the GOOS core team in implementing its strategic objectives and building outside partnerships.
- **Expert Panels**: The Physics and Climate, Biochemistry and Biology and Ecosystems Panels are vital for identifying user needs and evaluating the system.
- **The Observations Coordination Group:** the OCG strengthens GOOS implementation by coordinating the system through 12 global observing networks and OceanOPS.
- **The Expert Team on Operational Ocean Forecast Systems**: ETOOFS guides initiatives to improve capacity, quality and interoperability of ocean model forecast products.
- **GOOS Regional Alliances**: GRAs identify, enable and develop GOOS ocean monitoring and services to meet regional and national priorities.
- **Projects**: advancing innovation and expanding the observing system, services and product delivery by expanding into new areas and capabilities.
- **The GOOS office**: The GOOS office team works full time to enable the GOOS core to function, and to enable connection across the observing enterprise.

Through these components GOOS supports a community encompassing all those playing a role in the observing system: international, regional, and national observing programs, governments, UN agencies, research organizations, and individual scientists. By working together on observing tools and technology, the free flow of data, information systems, forecasts, and scientific analysis, this global community can leverage the value of all these investments.