OceanPredict

Advancing the science of ocean prediction

Strategy 2021 -2030

Foreword

Our planet is a place of many natural wonders with the ocean being one of the largest, covering over 70% of the Earth's surface. Most of human life is located along the continent's coastlines, and people use the ocean in many different ways from fishing to transport, energy production and recreation.

However, our oceans are under threat from many different stressors, mostly man-made. We need to ensure its protection and preservation for future generations and thus develop strategies for using the ocean in a sustainable manner.

Keeping the ocean healthy requires first and foremost knowledge of its status and workings. Understanding the ocean, monitoring and accurately describing and forecasting it provides valuable information, which properly communicated and distributed has many practical applications. It can provide solutions to reduce cross-ocean ship transit times, increase safety and efficiency of marine economic activity, better predict coastal impact of severe marine weather events, and provide insight into climate change impacts.

Additionally, the capacity to produce and distribute ocean information, can help counteract ocean ecosystem degradation, underpin renewable energy production from marine wind and ocean tides, better support sustainable fisheries, help increase effectiveness of government functions such as search and rescue, and marine regulations, to name but a few.

We define herein the full process of provision of routine oceanographic information needed for decision-making purposes as Operational Oceanography (also compare [here](#)).

Operational Oceanography encompasses many components, we identify as parts of the ocean information value-chain as it transforms raw ocean observations into comprehensive, regular and valuable ocean information (past, present and future) for different uses.

The ocean information value chain components represent multi-platform observation networks, data management systems, data assimilative prediction systems, dissemination/accessibility systems, serviced delivery, as well as the end users of ocean products.

OceanPredict is the international research and development network that accelerates and strengthens ocean prediction research globally and fosters its integration into operational ocean prediction systems worldwide. OceanPredict prediction systems form the centre component of the operational ocean information value chain, and over the next 10 years OceanPredict will work with international and intergovernmental partners to integrate with all value-

chain components, from observations to end-users to ensure its long-term sustainability.

As part of the UN Decade of Ocean Science, OceanPredict envisages contributing to delivering a thriving blue economy, better use and custodianship of ocean ecosystems through improving ocean prediction and underpinning this effort with the help of the OceanPredict ocean experts, as well as new linkages with an increasing number of the value-chain partners.

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About OceanPredict

OceanPredict is an international research and development network to accelerate, strengthen and increase the impact of ocean prediction.

OceanPredict's predecessor started in the late 1990's as GODAE, the Global Ocean Data Assimilation Experiment which was motivated by the Ocean Observation Panel for Climate (OOPC). Its purpose was to demonstrate the feasibility and value of the ocean observing system by assimilation of observation data into state-of-the-art ocean models for analysis and prediction purposes. In 2009, after a decade of successfully developing tools and demonstrating the utility of assimilation of ocean data into state-of-the-art global circulation models in near real-time, GODAE transitioned to GODAE OceanView (GOV), with the mandate to further enhance the underpinning science of operational oceanography in support of an improved utility of associated products to end users. GOV played a major role in increasing the global operational oceanography capability. From 2009 to 2019, global ocean and ice modelling and data assimilation systems were progressively improved, implemented and inter-compared.

In-situ and satellite data are now routinely assimilated into global and regional ocean models providing an integrated description of the current and future ocean state. Ocean observations, analysis and forecast products are readily accessible through major data and product servers, providing utility for many users and applications, from marine environmental monitoring, weather forecasting, seasonal and climate prediction, ocean research, maritime safety and pollution forecasting to defence, oil & gas industry, fisheries management and many more.

In 2019, GOV moved forward to become OceanPredict, to enhance ocean prediction within an overall operational oceanography context, reaching out to new partners and integrating OceanPredict in an international and intergovernmental context.

Over the next decade, through the UN Decade of Ocean Sciences ForeSea programme, OceanPredict will further advance ocean prediction science and capacity. More importantly, through the ForeSea programme, advances in prediction science and capacity will be done in step with partner groups covering observations, data management, digital twining, end user engagement and capacity training groups to ensure societal benefit and advances to the UN Sustainable Development Goals. Through ForeSea and in collaboration with ETOOFS[1], OceanPredict will contribute to broadening the operational capacity of further developing ocean forecasting

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[1] Expert Team for Operational Ocean Forecasting Systems (GOOS)

and analysis systems supporting the development from research to operations globally. The rapidly growing public awareness of the threats posed by climate change presents the opportunity for both OceanPredict and the UN Decade to provide societal benefit in supporting sustainable development, enhanced resilience and blue economy growth.

Why we need a new strategy

Many human interactions and operations in the ocean require environmental information, whether it is leisure, economic benefit, government mandate or climate change mitigation. Ocean information is essential to supporting evidence-based decisions on the pathway to sustainable development. Greater knowledge, based on continuous ocean observations, analysis, prediction, and information product consumption, will be needed to better adapt to, monitor, and understand climate change and variability, as well as ocean, weather, and environmental hazards.

With a changing ocean climate and the short-term nature of mesoscale[2] ocean dynamics, the observed past is not sufficient to describe present and future states of the ocean that a marine operator will face. The best ocean descriptions come from approaches that blend models and observations. Readily available descriptions and forecasts of ocean conditions are necessary to support effective Blue Economies, efficient and sustainable use of ocean resources, safe and efficient transportation, informed marine activity, etc.

This OceanPredict strategic plan is a reference document for the OP science team, its task teams, and groups that contribute to or benefit from operational oceanography. The implementation plan will detail the steps that will be taken to achieve the goals outlined below.

To support provision of operationally useful ocean information, a robust sustained ocean information value chain is needed (*figure 1*).

This value chain for operational oceanography has 6 major components.

1) **Ocean Observing System:** A robust, routine, permanent and well-supported network of ocean observations making global, regional, and coastal observation feasible (satellite and in-situ, real time and delayed mode, physics and biogeochemistry, etc.).

2) **Data Management and Monitoring System:** Ensuring that data is transformed, quality controlled, archived, and appropriately forwarded to

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[2] Mesocale ocean circulation features are associated with larger mean circulation features that become unstable and shed eddies. They are chaotic in nature and need to be assessed. Their scales can be 10-100 km's or so and they are an important mechanism for transporting water properties.

prediction systems and service delivery centres.

3) **Prediction System:** Transforming numerical models of ocean physics/biogeochemistry (in future extending to biological/ecological approaches) as well as ocean observations into routine best estimates of physical and biogeochemical ocean conditions (past / present) and forecasts.

4) **Product and Data Delivery:** Archiving, interface and delivery systems ensuring ease of access to users, fitness of purpose and monitoring of user uptake.

5) **Services:** Value adding service providers that deliver fit-for-purpose products to specific user groups.

6) **Users:** A client group that uses operational oceanographic products and provides feedback on the utility and usefulness of the operational oceanographic information services they receive that values observation and prediction system contributions to better informed end user decisions.

Defining an operational oceanography framework with standards and best practices for the ocean information value chain enables assessment of the above components in enabling end use benefit. It enables systematic review to improve prediction, observing, data management, distribution and service systems.

We anticipate increased user demand throughout the Decade of Ocean Science for Sustainable Development (2021-2030) and we expect strong international focus on improving our understanding and monitoring of the world's oceans. The driving purpose is to inform initiatives to achieve stable sustained Blue Economy growth, promote equitable and integrated use of the ocean, and protect the ocean ecosystem. This purpose catalyses increased demand for readily available, reliable, and accurate ocean observations, analysis, and forecast information products across multiple scales will grow. Addressing this demand requires sustained evolution and coordination, from research to operations, of ocean prediction systems on local, regional and global scales.

The UN Decade of Ocean Science for Sustainable Development 2021-2030 is a call for action, within the science community and beyond, in order to face the challenges placed upon our oceans by combined climate and human pressures, and to define a new and sustainable future for the ocean and the life it supports. Additionally, the World Meteorological Organisation is

evolving from weather prediction to earth system prediction that includes predicting the ocean.

Ocean Predict is well placed to contribute to these international initiatives. OceanPredict will strategically engage with relevant national and international organisations and programmes. With its network of forecasting centres, international forums, national agencies and academia, OceanPredict is rightly positioned to lead and steer operational oceanography towards these aspirations.
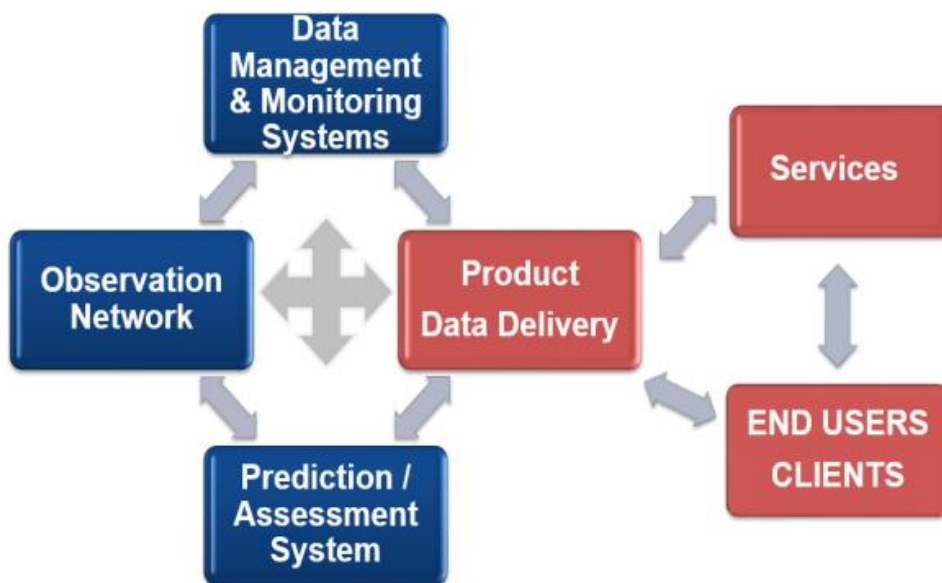

Figure 1: Ocean information value chain for Operational Oceanography. OceanPredict is focused on the Prediction /Assessment System but helps ensure the overall societal benefit by collaborating with other component groups off the value chain. Blue boxes refer to information production, orange boxes refer to information uptake/dissemination. Feedback is implicit in this chain with 2-way arrows throughout.

Our Vision

A robust international coordination mechanism to build the ocean prediction capacity of the future within a co-designed equitable international operational oceanography framework

We envision an efficient full ocean information value chain, which is scientifically sound and provides useful, affordable and sustainable solutions for governmental, economic and societal needs.

The indispensable basis for building the future ocean prediction capacity is a sustained ocean observing system. On an ongoing basis OceanPredict is dedicated to work with the Global Ocean Observing System (GOOS), Committee on Earth Observation Satellites (CEOS), and associated groups to co-design and co-develop the ocean observing system of the future to deliver essential information needed for safety, well-being and prosperity.

Improved data assimilation methods, assimilation of new observations, and the improvement of model prediction systems, for example using ensemble forecasting methods, as well as advancing coupled prediction by working with NWP centres will provide advanced information on the ocean for various applications.

Increasing uptake of better ocean products by a growing number of users will be supported through improved dissemination and delivery mechanisms and ocean services, including enhanced quality control and verification tools. It will also offer users to take advantage of fit-for-purpose ocean products to increase long-term confidence in operational oceanography.

OceanPredict will nurture and enable growth of new operational systems around the world by offering relevant expertise through partnerships and training, as well as defining best practices, and standards. Led by ETOOFS we will contribute to finalising the "Guide to operational oceanography" and facilitate its implementation. This will provide a baseline for capacity growth in ocean prediction enabling faster implementation of leading-edge research such as machine learning and artificial intelligence by new prediction groups.

Improved visibility of ocean prediction efforts, successful collaboration with value-chain partners through the UN Decade initiative and showcasing the benefits of enhanced ocean

knowledge and products will provide better information to governments and society about emerging ocean issues and solutions for mitigation, thus increasing the impact of operational oceanography for sustainable development, blue economy, and society, and will allow us to be better prepared for new challenges.

Our Mission

To drive the improvement of the science, capacity, efficacy, use, and impact of ocean prediction systems by contributing to a seamless ocean information value chain, from observations to end users, for ecosystem, economic and societal benefit

The overarching goal is to contribute to a seamless ocean information value-chain, from observations to end users, to achieve economic and societal benefits while preserving healthy ecosystems.

To reach this goal, OceanPredict through the Ocean Decade, will increase synergy with current and new partners, such as operational forecasting and research centres, observation agencies, science groups, and intergovernmental organisations. OceanPredict will also engage with partners further afield through suitable collaborations and joint activities to establish a large network that will support the advancement and expansion of operational oceanography.

Enhanced communication and a mutual drive to improve the science, capacity, efficacy, use and impact of ocean prediction systems is at the core of this endeavour. OceanPredict will collaborate efficiently, to strengthen the science to underpin ocean prediction, and additionally integrate its activities and knowledge with other components of the ocean information value chain to enable societal and end use value.

We aim to develop and represent the central part of the ocean information value chain, and to coordinate its integration into other value chain components; the ocean observing system and the end-user services. We rely on close collaboration with our partners so that the use and value of ocean products and services for the user is maximised.

OceanPredict provides a large range of expertise, experience and international science networks as well as long-term standing science coordination which, together with the willingness to improve the current ocean prediction systems, makes it very well placed for its mission.

The OceanPredict supported ForeSea Decade program will enable collaboration and mechanisms to build a seamless international ocean information value-chain and be a strong contribution to the UN Decade of Ocean Science for sustainable development.

OceanPredict is inclusive and open to support upcoming ocean scientists on their way of learning. OceanPredict is dedicated to engaging in outreach activities through science symposiums, summer schools, virtual lecture series and other targeted training and networking opportunities.

Strategic Objectives

Our objectives are focused on delivering our vision of building the ocean prediction capacity of the future and contributing to a seamless ocean information value chain, from observations to end users, for economic and societal benefit

> →   Building the ocean prediction capacity of the future

Advance ocean prediction science and operational capacity to maximise the impact of operational oceanography outcomes on marine science, sustainable marine economies, and society.

1. **Data assimilation:** Improving ocean data assimilation capacity

2. **Verification:** Research to improve monitoring for ocean prediction accuracy and utility by developing a common framework by which operational centres can participate in regular system inter-comparisons and verifications

3. **Observing system evaluations:** Contributing to projects and assessment to better design observing systems and assess the observation impact on prediction

4. **Models:** Collaborating with various science R&D groups through OceanPredict task teams to improve ocean prediction
   a. in shelf seas and coastal environments
   b. for biogeochemical variables and ecosystem indicators
   c. in polar/sea-ice environments
   d. for coupled environmental prediction systems (including earth systems)
   e. for ensemble (probabilistic) prediction approach
   f. for fish stock assessment and prediction
   g. for pollution applications
   h. for global and climate applications

5. **Visualisation:** Collaborating with ocean product developer and ocean services to improve visualisation and accessibility tools for predictions and observations

Close collaborations with partners along the ocean information value chain, intergovernmental organisations, research groups and users are vital for the successful implementation of a long-term ocean information system from observations to end users.

6. **Value-chain:** Nurturing sustained productive dialogues with global and regional in-situ and satellite observing system agencies, coordinating R&D efforts with intermediate value-chain users and contributors such as coastal and biogeochemical prediction systems, and building close relationships with science partners and user groups to create a framework of operational oceanography.

7. **Operationality**: Supporting the transition from research and development to operations of prediction system improvements by reporting relevant scientific developments to ETOOFS and the OceanPredict systems.

8. **International collaborations:** Actively contributing to the UN Decade of Ocean Science goals for Sustainable Development.

9. **Downstream:** Promoting access to data and information products and enhanced uptake of ocean analysis and forecasting products with governments, the public and private sector.

→ Co-design and co-develop ocean prediction and ocean observing systems

Working closely with the observing system community to co-design and co-develop observing systems which are fit for purpose and deliver value.

10. **Partnerships:** Develop strong partnership with observation and NWP agencies with the objective to co-design/co-develop ocean observing and prediction systems

11. **Monitoring and assessments:** Set up and improve monitoring systems for assessing the impact of observations and sharing results with associated partners. Increase use of these systems by operational centres.

- o Class 4 Metrics (IV-TT) Prediction vs observation analysis
- o Reports on observation impacts in ocean prediction systems

12. **New observations:** Engage key-observing and key-end-user-focussed partners to evaluate and communicate impact of new ocean observing systems

13. **Improving observation and prediction systems:** Fostering and coordinating the development of emerging areas and new ocean monitoring, modelling and assimilation components to improve ocean forecasting and observing systems for both operational implementation and research (including physical, biogeochemical, and biological/ecological observations)

→ Increasing societal impact of ocean prediction

Evaluating the impact of ocean prediction products for intermediate and end users to understand the value and benefit and to adjust prediction outcomes for better usage.

14. **Routine impact assessments for user benefit:** Conducting routine impact analysis for various aspects of ocean observing systems on improving end user experience, as well as impact on other environmental prediction components

15. **New capabilities:** Enhancing research value and utility for operational prediction centres through targeted collective multi-disciplinary projects on new capabilities for operational oceanography in cooperation with other relevant international research programmes, including adopting machine learning/AI where appropriate and beneficial.

16. **Outreach - learning:** Promote an increase in understanding and uptake of ocean prediction science and products by promoting knowledge and sharing of information equitably around the world. This will be achieved through organising and preparing symposia, summer schools, training workshops, online training and ocean literacy material, as well special publications. The goal is to nurture a growing community of scientists, students and public in general, on operational oceanography covering ocean observations, ocean prediction science, operational prediction

systems, products, end use tools, downstream services and societal benefits.

17. **Outreach – supporting new operational system utility:** Collaborate with upcoming prediction systems to support the transition from research to operations and facilitate end use

Outlook

OceanPredict, formerly GODAE and GODAE OceanView, is providing coordination and leadership in consolidating and improving global and regional ocean prediction systems. As such, it will increasingly engage in long-term partnerships to grow the integrated ocean information value chain for societal and economic benefit.

This is a big challenge and will require all our strength. We will focus on achieving our strategic objectives and develop an OceanPredict Implementation Plan with support from and in collaboration with our partners.

We hope that the enthusiasm for the path ahead will be shared among our colleagues and fellow ocean partners and that the outcome from our efforts will be to the benefit of many.