PREDICTING THE GLOBAL COASTAL OCEAN

STRATEGY AND IMPLEMENTATION PLAN

A PROPOSAL TO THE UNITED NATIONS DECADE OF THE OCEAN

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FOREWORD

The document describes the Science and Implementation Strategy for a Programme called "*Predicting the Global Coastal Ocean*" dedicated to partially fulfill the United Nations Decade of Ocean Science for Sustainable Development objectives of a predicted, healthy and safe ocean. The Programme acronym is CoastPredict.

In January 2020 the first Science Strategy was presented at the UN Ocean Decade Workshop in Venice. Between February and June 2020, a consultation was open at the following web page: https://www.coastspredict.org/. Almost 200 scientists, practitioners and managers from academia, government and the private sector from 36 countries have endorsed the initiative with signatures and comments.

Using inputs from the collected signatures and discussion by the initial steering committee of the Programme, this revised document was prepared adding a draft Implementation Strategy.

The initial steering Group

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SCIENCE AND TECHNOLOGY STRATEGY

HTTPS://WWW.COASTSPREDICT.ORG/

BACKGROUND

The basic concept of a Global Coastal Ocean was defined about a decade ago in five Volumes of The Sea (Vols. 10 to 14, Harvard University Press). The revised definition is:

- *the coastal ocean - that area, extending **inshore** from the estuarine mouths to river catchments affected by saltwaters and **offshore** from the surf zone to the continental shelf and slope where waters of continental origins meet open ocean currents.*

In other words, the coastal ocean is the interface area where land, hydrology, ocean and atmosphere interact in a multiplicity of space and time scales and give rise to the highest ocean productivity and the strongest interaction between fresh waters, including glacier waters, and salt waters.

We now believe that, after thirty years of development in ocean predictions and operational oceanography, we are capable of understanding and predicting this complex zone where most of the human population live and the impacts of climate change will be amplified.

Most sustainable development goals (SDGs) consider the socio-economic and environmental problems connected within this crucial area. All these goals require increased knowledge and advanced predictions of the global coastal ocean in order to provide solutions for the management and sustainable exploitation of the resources. The Programme "Predicting the Global Coastal Ocean", shortly CoastPredict, has been designed to substantially improve our capacity to address the SDG targets.

CoastPredict contributes to the UN Ocean Decade objective of "A predicted ocean" by improving our understanding of the coastal area processes using a multi-disciplinary and integrated approach and focusing on the many common worldwide features of the coastal ocean that we need to understand for knowledge based and sustainable management. The major science challenge is to advance the understanding of the role played by the coastal ocean in the global ocean dynamics, from short time scale events to climate.

Observing systems and numerical models will be developed to drive a transformative change on how to predict the coastal ocean at global

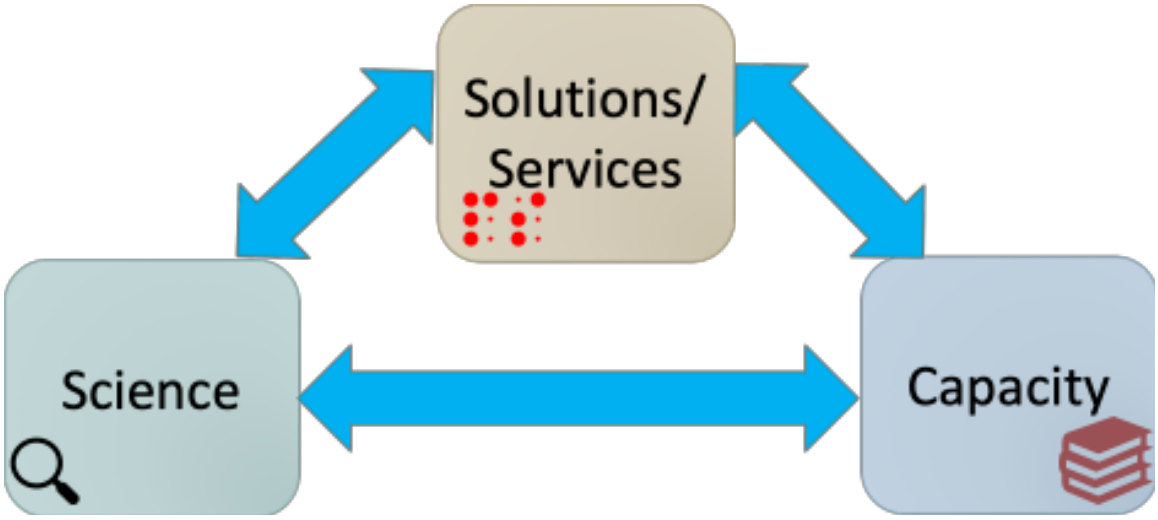
scales, bringing together diverse scientific, technological and socio-economic communities to co-design the system at the global level.

Last but not least, the Oceanobs19 Conference statement (http://www.oceanobs19.net/wp-content/uploads/2019/09/OO19-Conference-Statement_online.pdf) considered two high priority efforts for the next decade:
1) Advance the frontiers of ocean observing capabilities from the coast to the deep ocean, … at the boundaries between … land, … freshwater, and human populated areas;
2) Improve the uptake of ocean data in models for understanding and forecasting of the Earth system.

The UN Decade of the Oceans initiative is a unique opportunity to advance the science of the global coastal ocean and the innovative solutions to its challenging problems.

THE PROGRAMME IN A NUTSHELL

CoastPredict will coordinate scientific advancements and technological innovations following three pillars:



CoastPredict outcomes and outputs will be:

1. *Integrated and comprehensive knowledge of the global coastal ocean from short time scale events to climate, including impacts of societal drivers;*
2. *Integration of coastal and open ocean observing and modelling systems;*
3. *Improved, multidisciplinary and extended range predictive capabilities for the coastal zone;*
4. *Innovative and sustainable applications for coastal solutions/services.*

DRIVING SOCIETAL NEEDS

The 17 SDGs are the primary drivers for CoastPredict.

In summary:

- → Coastal urbanization exacerbates the need for advanced monitoring and predictions of coastal inundation, of coastal pollution, of coastal habitat health and multi-hazards;
- → Climate change and related extremes are affecting population resilience at the coasts, thus coastal impact studies need to focus on extended range predictions, considering new monitoring systems, sea level rise and other coastal climate trends;
- → Sub-seasonal to seasonal (S2S) predictions in the coastal zones need to be improved through a deeper understanding of the multi-scale interactions and processes occurring at the coasts and along the shelf/open ocean region;

→ Coastal ocean health issues require an innovative combination of observing and numerical prediction systems in order to evaluate solutions and protection measures;

→ Assessments of policy target effectiveness in the coastal areas, and the connected catchments require the development of innovative Earth System numerical modelling with appropriate coupling between the meteorological, hydrological and oceanographic factors along the coasts.

→ Capacity Development supporting diverse capabilities and cultures

The contribution that CoastPredict could offer to the 17 SDG targets is discussed in the Table below.

SDG	Contributions by CoastPredict
	**Sustainable blue economy** using a science-based approach that considers coastal predictions for management of resources and environmental protection.
	**Fishery and mariculture** rely on the accuracy of the "predicted" ocean
	**Coastal oceans are essential components of human's well-being** and coastal ocean predictions help to preserve this natural resource.
	**Coastal ocean literacy** is a pre-requisite for responsible citizenship at public, private and corporate levels.
	**Coastal ocean solutions** will consider diversity issues at all levels of the CoastPredict development.
	Predict **salinization of drinkable waters, understand and predict salt intrusions in rivers**, develop integrated water management plans in the coastal areas.
	Improve the use of **renewable energy** from the coastal zone winds, currents (including slope currents), waves and the ecosystem resources using the predicted ocean products
	Promote **safe working conditions** for the coastal ocean communities using ocean prediction products

	Innovative coastal tourism, mariculture, transport, gas/oil extraction, safe transport and advanced port management using **coastal prediction products**
	Promote the **inclusive participation of the coastal communities** in the design and implementation of solutions, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status
	**Reliable and extended coastal inundation predictions,** hazard mapping of coastal pollution from different sources eliminating dumping in the coastal zone
	Connect the "predicted coastal ocean" to scientific and technological capacity to move toward more sustainable **seafood production and consumption in the global coastal ocean.**
	Promote **downscaling of climate change scenarios in the coastal zone**, designing new coupled ocean-atmosphere-land-hydrology at the local scales and define impacts of different scenarios, including coastal sea level changes and extreme events at the coasts
	**Protect and restore coastal habitats, develop nature-based solutions for coastal erosion using coastal prediction products. Develop early warning systems for multi-hazards on the coasts.**
	Improve the understanding of aquifer water flows and the management of the **adverse effects of coastal area saltwater intrusions**.
	Analyze and implement plans for coastal transboundary water problems, enhancing the collaboration of countries in setting the observing and modelling system that will enable **water resources and their part of the global coastal ocean to be peacefully managed.**
	Mobilize resources for the co-design between scientists and coastal stakeholders **on the science, solutions/services and capacity in the global coastal ocean**

DRIVING SCIENCE IDEAS

The role of the coasts in the large-scale ocean circulation has been recognized since the beginning of modern oceanography and meteorology. Coasts are the waveguide for tidal waves and Kelvin waves, and play a key role in the dissipation of ocean energy. They are sources of energy for baroclinic Rossby waves crossing the ocean basins and accumulating energy in western boundary currents. Coasts shape specific upwelling/downwelling processes and are regions of freshwater influence from rivers and glaciers. Coasts interact strongly with slope currents, and they are the sites where marine biology, biogeochemistry and physics connect to produce the largest atmospheric CO2 sinks.

Despite these key issues, the "generic" understanding of the global coastal ocean is still lagging behind other topics in oceanography, probably because of the fragmented scientific approach related to the varying coastal specificities. However, Robinson and Brink (2010) attempted to define the concept of the "global coastal ocean", highlighting that a common scientific approach to studying the different coastal areas is possible. **This is the key idea for this Programme.**

In order to achieve the goal of understanding the different but similar "global coastal ocean" areas several scientific questions need to be investigated, including:

- *The scientific definition of the "global coastal ocean", its physical and biochemical role in the large scale ocean circulation and ecosystem dynamics;*
- *The understanding of factors that affect the accuracy and limits on the predictability of the coupled atmo-hydro-land-ocean system at the coasts and the development of Limited Area Coastal Earth System Modelling;*
- The sediment-light-nutrient-physics nexus in the coastal zone, its connection to the nutrient limitation paradigm in the open ocean *and its effects on the predictability of coastal marine food webs and coastal carbon cycle;*
- *The optimal design of a multi-scale multidisciplinary global observing system which considers both the open ocean and the coastal observations;*

- *The development of new technologies and methodologies capable to resolve spatial and temporal scales of coastal processes for monitoring the essential ocean variables.*
- *The development of a coastal observation data management system to be synchronized and harmonized with the developments of the Ocean Data Information System (ODIS) being developed during the Decade;*
- *The methods for trusted data/information and interoperability across the value chain;*
- *The establishment of limited area modelling (nesting, downscaling) for increased process inclusion and resolution at the land-ocean interface and offshore, including probabilistic and ensemble coastal forecasting;*
- *The optimization of data assimilation methods in the coastal ocean for ocean predictions, multi-scale capability of data assimilation algorithms, usage in unstructured grid models;*
- *The investigation and predictions of the salinization of inland coastal waters, both surface and underground, together with coastal erosion and geomorphological changes;*
- *The development of coastal urban meteorology and oceanography concepts and tools;*
- *Sustainable Mariculture and Capture Fisheries;*
- *The economic, ecological and societal carrying capacity of the coastal ocean*

Some of these science challenges will be matched to specific solutions and services to be developed by Projects as proposed in the Implementation Strategy offered in the next section.

IMPLEMENTATION STRATEGY

HTTPS://WWW.COASTSPREDICT.ORG/

IMPLEMENTATION CONCEPT

Solutions/services for the global coastal areas rarely involve the setting of a monitoring and prediction system to assess impacts from events to climate trends. For example, solutions for storm surge predictions considered mainly depth-integrated modelling thus preventing the direct consideration of the climate change sea level trend due to warming/freshening of the oceans. In addition, solutions/services have not been adequately intercompared between coastal areas. For example, prediction and monitoring systems for the loss of coastal coral reefs across the world oceans has been different for no specific reasons.

The CoastPredict initiative has, among others, the challenge to define coastal areas of the global ocean where similar solutions can be implemented, tested and evolved or, on the contrary, where different solutions are required. The first attempt to classify the different coastal areas of the world ocean was done by Robinson and Brink (2010) and here is shown in Fig.1.

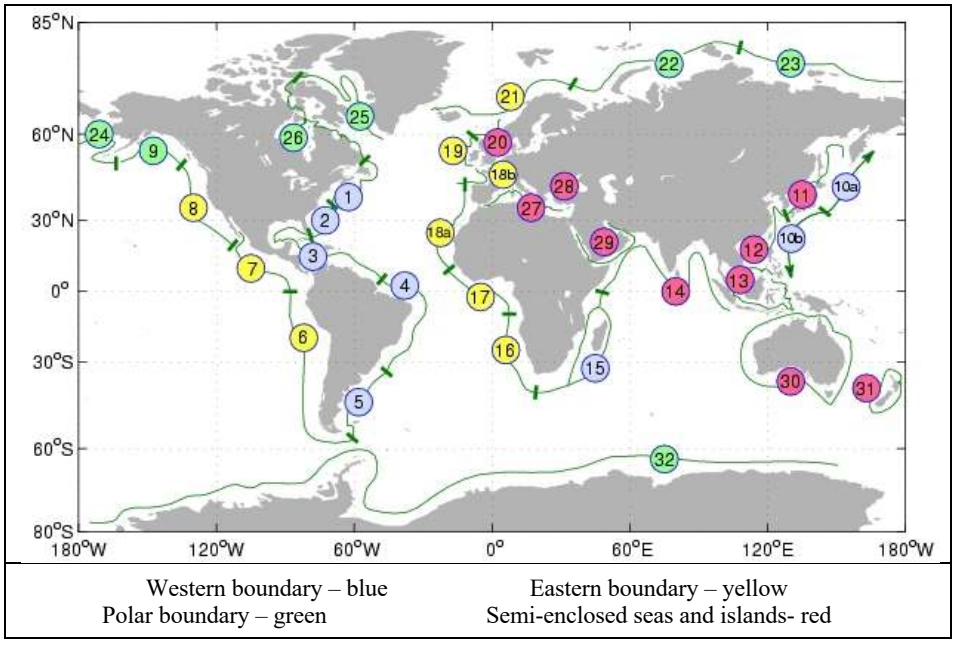


Fig. 1 From Robinson and Brink, The Sea, Vol. 14 (2010)

This coarse grain classification already gives an idea that four predictive systems, solving issues of societal importance, using advanced science understanding and solutions, could be required. The requirements could be different in terms of both observing and modelling systems as well as for the predictability. This is the basic idea which will guide the implementation of CoastPredict: starting from societal needs develop

solutions in similar and/or contrasting ocean areas and understand what the different requirements are, demonstrate the solution effectiveness and build capacity in the local communities.

One of the key concepts to be used in building the programme implementation is the "Ocean Value Chain" process (see Fig. 2). CoastPredict will enhance the "basic information infrastructure" because it will develop integrated open-to-coastal-ocean prediction services that will be based on openly available large scale prediction information. The coastal predictions will set the fitness-for-use of the global scale open ocean information and will address the gaps in observing and forecasting for the coastal areas. The Programme will also improve services/solutions by extensively using the information products of the coastal prediction systems to arrive to fit-for-purpose information for the end-user communities.
The "basic" and "tailored" information data products will undergo different levels of quality assessment during the duration of CoastPredict to arrive at the end to establish standards for quality assurance in the different parts of the Ocean Value Chain.

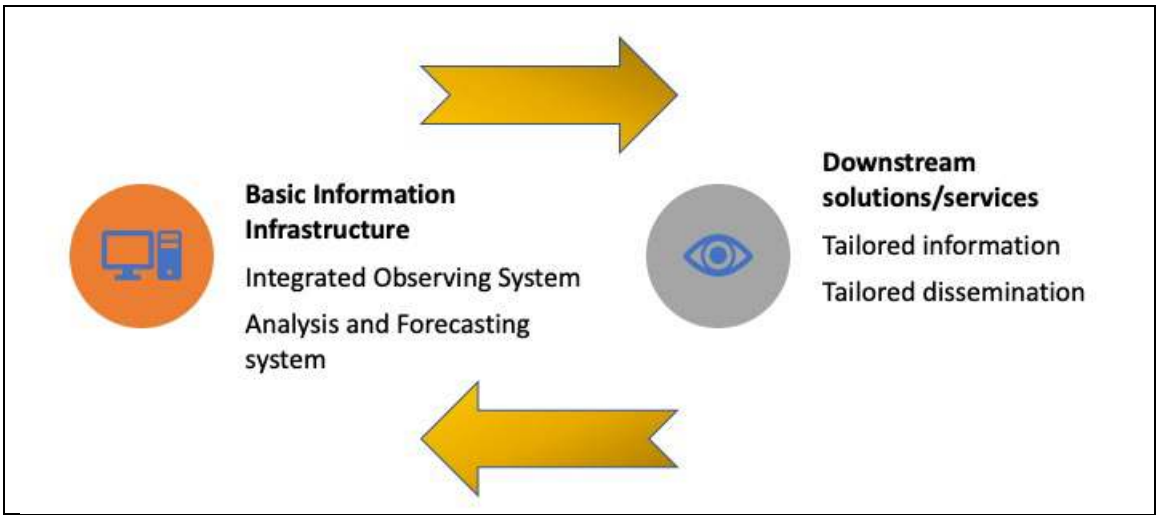


Fig. 2 Schematic of the "Ocean Value Chain" process

THE STEERING STRUCTURE

For such a large initiative, we need a solid coordination and management structure that will monitor and ensure the activities are carried out on time.

For the UN Ocean Decade there is not a specific structure recommended so we devised one that should have the capability to overview the work for the entire 2021-2030 period.

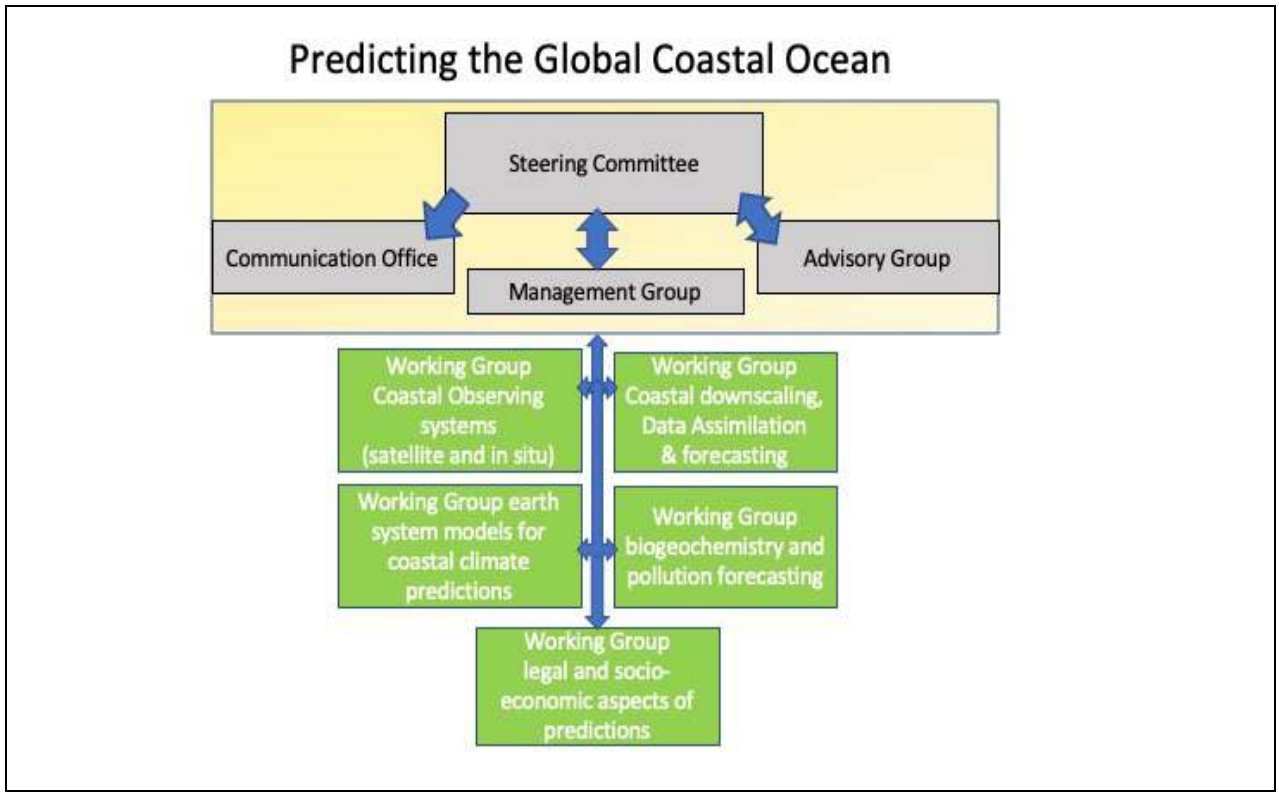


Fig. 2 The management structure of Coastspredict

Here we describe the role of each structural group in Fig. 2:

A. ***Steering committee:*** *it is composed by scientists and managers from academia, government and the private sector that also belong to the working groups. It is keeping the overall view of the program and the coordination of the projects. It is chaired by a Chair and co-Chair who are nominated by the Steering Committee at its first meeting and they will be in charge for 3 years with the possibility of a 2 years re-nomination. The Committee will be responsible for*

drafting the updates of the general science and implementation strategy in consultation with the Advisory Group. It will include representatives of other linked UN Decade Projects.

B. ***Advisory Group:*** *it is composed of representatives of IOC and WMO structural elements, the Unesco International Hydrology Program, the United Nation Environment Program (UNEP) and international programmes such as GEO, Geo-BluePlanet, OceanPredict, WCRP. Its aim is to advice on the strategic implementation and have an external guidance on the Program. Some participants to the Advisory group could also be part of the Management Group.*

C. ***Management Group:*** *it has the mission to follow the everyday activities of the Programme, connect with sponsors and the parent organizations, IOC and WMO. It is chaired by the Chair and the Co-chair of the Steering Committee. It will be composed of representatives of the Steering Committee, in particular the coordinators of the Projects, and representatives of the Advisory Group (as many as necessary). The composition will be evaluated every three years and changes will be approved by the Steering Committee and the Advisory Group.*

D. ***Communication Office:*** *it will work under the guidance of the Steering Committee to develop activities with strategic communication components. It will advise all teams on best practices as it relates to strategic communications.*

E. ***Working groups:*** *these groups have the mission to discuss methodologies, best practices, technical issues and steering of the projects. The working groups should be composed of the coordinators of the projects and other project partners that could help the maintain efficient cross-disciplinary and cross-project activities.*

INITIAL THEMES FOR PROJECTS

Several ”Decade Projects” should be created on the basis of scientific and implementation challenges in the contrasting coastal areas.

At this moment, five crucial themes are envisaged:

1) ***The physical-sedimentary-biological-chemical coastal ocean dynamics and their predictability***. *This project tries to solve the nexus of the role of the coastal ocean in the large scale ecosystem dynamics.*
2) ***Multi-hazard coastal prediction systems***. *This project develops the integrated observing and modelling system for forecasting capable to sustain innovative early warning systems and hazard mapping from extreme events to S2S time scales.*
3) ***Climate change predictions in the coastal zone***. *This project develops the earth system coastal modelling for the long term predictions in the coastal areas, developing the validation/calibration and assimilation methods in order to keep track of uncertainties and arrive at the local coastal scales.*
4) ***Predictions and scenarios for coastal protection (incl. Nature Based Solutions)***. *This project develops the observational data collection requirements and the methodologies of multi-scale, multi-model predictions for assessing engineering and natural solutions for the protection of the coastal zone from adverse effects of land based pressures and climate change trends.*
5) ***Forecasting and applications for sustainable coastal economic activities.*** *This project connects prediction products to socio-economic activities toward sustainable development. Mariculture, local fisheries, tourism, ports, shelf renewable energy production socio-economic data should be coupled with multi-hazard early warning systems for safety and to climate change predictions to maintain sustainable levels of exploitation of resources.*

Projects should be built on the basis of these themes and proposed by the S&T Committee and Advisory Group at their first meeting.

Projects should be formulated following some basic principles, i.e.:

- Have a clear stakeholder engagement plan
- Have at least three ocean areas of implementation and study (relocatable solutions are essential), one of which in a developing country.
- Include data management and best practices for open access data
- Provide end-to-end demonstrations
- Multi-national, multi-disciplinary and diversity balanced groups
- Make an effort to use new methodologies and technologies within the different aspects of the project;
- Include a plan for after-the-project continued development of the basic information infrastructure upgrades and solutions/services with adequate public/private partnerships;
- Include capacity building and ocean literacy activities.

PHASING THE IMPLEMENTATION

CoastPredict will normally have 5 phases. They approximately will consist of:

1) a First Phase (1,5 years, 2020-2021) where the Strategic science and implementation Plan will be completed, the steering and advisory committees formed and the first round Projects (FR Projects) designed. Links with potential financial partners will be scrutinized in this phase.

2) a Second Phase (3 years, 2022-2024) where the FR Projects will be carried out in different world ocean coastal areas;

3) a Third phase (2 years, 2025-2026) where the FR Project outcomes will be reviewed by scientists and stakeholders driving the design of the follow-up Projects for the next three years;

4) a Fourth phase (3 years, 2027-2029) where second round (SR) Projects, including revised FR and new Projects, will be carried out;

5) a Fifth phase (2030) planning the further exploitation of the CoastPredict outcomes.

The duration of the FR and SR Projects will be decided on the basis of the scope and funding required. Every Phase will include extensive dissemination and communication activity.

LINKED INITIATIVES

The initial steering Group has entertained several conversations with other International and UN Decade initiatives and received positive feedback for the coordination among the projects.

The outstanding parent program of CoastPredict is OceanPredict (http://oceanpredict19.org/) which in the past twenty years has organized the large scale world ocean predictions standards and developed a group of Coastal Ocean and Shelf Sea Task Team that started the international coordination for coastal predictions. The OceanPredict Governing Board was supportive of CoastPredict and key scientists from OceanPredict will be sitting in the CoastPredict Steering Committee.

The Global Ecosystem for Ocean Solutions (GEOS) UN Decade proposed Programme, is coordinated with CoastPredict: Emanuele Di Lorenzo is part of the initial Steering Committee for CoastPredict and Nadia Pinardi will sit in the GEOS Steering committee to ensure maximum coordination.

The programme "Developing Ocean Observing Capacity During the UN Decade for Ocean Sciences for Sustainable Development: A Community Prospectus" has publicly supported CoastPredict on the web page comments and its leaders have signed the CoastPredict web page. The key actors of this program will be inserted in the CoastPredict Steering Committee.

Last but not least, informal presentations at IOC (Expert Team of Operational Ocean Forecasting Services meeting, December 2019) and at WMO have paved the way to coordinate CoastPredict with the relevant structures of the two organizations.

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