EuroSea

Improving and Integrating European Ocean Observing and Forecasting Systems for Sustainable use of the Oceans

Table 1: *List of participants*

No.	Acronym	Participant organization name	Country
1 (CO)	GEOMAR	GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel	DE
2	EuroGOOS*	EuroGOOS	BE
3	UNESCO	United Nations Educational, Scientific, and Cultural Organization - UNESCO	FR
4	MOI*	Mercator Ocean International	FR
5	UNIBO	Alma Mater Studiorum - Universita di Bologna	IT
6	MI	Marine Institute	IE
7	CSIC	Agencia Estatal Consejo Superior de Investigaciones Cientificas	ES
8	ENS	Ecole Normale Superieure	FR
9	CLS*	Collecte Localisation Satellites SA	FR
10	OGS	Instituto Nazionale di Oceanografia e di Geofisica Sperimentale	IT
11	CMCC*	Fondazione Centro Euro-Mediterraneo sui Cambiamenti Climatici	IT
12	UiB	Universitetet i Bergen	NO
13	UKRI	United Kingdom Research and Innovation	UK
14	SU	Sorbonne Universite	FR
15	SOCIB	Consorcio para la construccion, equipamiento y explotacion del Sistema de Observacion Costero de las Illes Balears	ES
16	ECMWF	European Centre for Medium-Range Weather Forecasts	UK
17	IO PAN	Instytut Oceanologii Polskiej Akademii Nauk	PL
18	IfW	Institut für Weltwirtschaft	DE
19	Euro-Argo Eric	Euro-Argo Eric	FR
20	CNRS	Centre National de la Recherche Scientifique	FR
21	IFREMER	Institut Francais de Recherche Pour L'Exploitation de la Mer	FR
22	RBINS	Institut Royal des Sciences Naturelles de Belgique	BE
23	Sciencethics*	Institut de Science et Ethique	FR
24	ISPRA	Istituto Superiore per la Protezione e la Ricerca Ambientale	IT
25	IEEE*	IEEE France Section	FR
26	EMB*	European Marine Board IVZW	BE
27	IMT	Institut Mines-Télécom	FR
28	OceanNext*	OceanNext	FR
29	AZTI*	AZTI Fundazioa	ES
30	EPPE	Puerto de L'Estado	ES
31	ACRI*	ACRI-ST SAS	FR
32	ARUP*	Ove Arup & Partners International Limited	UK
33	HCMR	Hellenic Centre for Marine Research	GR
34	NIVA*	Norsk Institutt for Vannforskning	NO
35	MetOffice*	Met Office	UK

36	EMSO ERIC	European Multidisciplinary Seafloor and water column Observatory - European Research Infrastructure Consortium	IT
37	PLOCAN	Consorcio para el Diseño, Construcción, Equipamiento y Explotación de la Plataforma Oceanica de Canarias	ES
38	UBREMEN	Universitaet Bremen	DE
39	UPORTO*	Universidade do Porto	PT
40	SZN	Stazione Zoologica Anton Dorhn	IT
41	AWI	Alfred-Wegener-Institut, Helmholtz-Zentrum für Polar- und Meeresforschung	DE
42	ETT*	ETT SPA	IT
43	Nologin*	Nologin Consulting, S.L.	ES
44	UPC	Universitat Politecnica de Catalunya	ES
45	DMI	Danmarks Meteorologiske Institut	DK
46	TalTech*	Tallinna Tehnikaulikool	EE
47	CNR	Consiglio Nazionale delle Ricerche	IT
48	IRD	Institut de Recherche pour le Développement	FR
49	UCAM	The Chancellor Masters and Scholars of the University of Cambridge	UK
50	Xylem*	Xylem-Aanderaa	NO
51	WMO	Organisation Meteorologique Mondiale	FR
52	UERJ	Universidade do Estado do Rio de Janeiro	BR
53	UFPE	Universidade Federal de Pernambuco	BR
54	MUN	Memorial University of Newfoundland	CA
55	DAL	Dalhousie University	CA

*non-public partners

Table 2: *List of acronyms*

ADCP	Acoustic Doppler Current Profiler	DESCA	Development of a Simplified Consortium Agreement
AORA	Atlantic Ocean Research Alliance	DFO	Department of Fisheries and Oceans
ASV	Autonomous Surface Vehicles	DG	Directorate-General
BG	Blue Growth	DIC	Dissolved Inorganic Carbon
BGC	Biogeochemical	EB	Executive Board
BOOS	Baltic Operational Oceanographic System	EC	European Commission
BP	Best Practices	ECMWF	European Centre for Medium-Range Weather Forecasts
C3S	Copernicus Climate Change Service	ECV	Essential Climate Variable
CBD	Convention on Biological Diversity	EEA	European Environment Agency
CFP	Common Fisheries Policy	EFI	Extreme Forecast Indices
CIOOS	Canadian Integrated Ocean Observing System	EMODnet	The European Marine Observation and Data Network
CLIVAR	Climate and Ocean: Variability, Predictability and Change	ENVRI-FAIR	Environmental Research Infrastructures building Fair Services Accessible for Society, Innovation and Research
CMEMS	Copernicus Marine Environment Monitoring Service	EOOS	European Ocean Observing System
COP	Conference of the Parties	EOV	Essential Ocean Variable
CVOO	Cape Verde Ocean Observatory	EPA	Environmental Protection Agency
DBCP	Data Buoy Cooperation Panel	ESA	European Space Agency
DCF	Data Collection Framework	ESA CCI	ESA Climate Change Initiative

ESFRI	European Strategy Forum on Research Infrastructures
EU	European Union
EU-ETS	European emission trading scheme
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
EurOcean	European Centre for Information on Marine Science and Technology
EUSAIR	EU Strategy for the Adriatic-Ionian Region
FAIR	Findable, Accessible, Interoperable, and Re-usable
FNEO	Fernando de Noronha Observatory
FOO	Framework for Ocean Observing
FPRL	Framework Processes Readiness Levels
G7	Group of Seven
GA	General Assembly
GCOS	Global Climate Observing System
GDB	Gender and Diversity Board
GEO	Group on Earth Observations
GEOSS	Global Earth Observation System of Systems
GESAMP	Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection
GlobalHAB	Global Harmful Algal Blooms
GLOBICOM	Global Omics Observatory Network
GLODAP	Global Ocean Data Analysis Project
GLOMICON	Global Omics Observing Network
GLOSS	Global Sea Level Observing System
GNSS	Global Navigation Satellite Systems
GNSS-MR	GNSS Multipath Reflectometry
GOA-ON	Global Ocean Acidification Observing Network
GODAE	Global Ocean Data Assimilation Experiment
GOOS	Global Ocean Observing System
GROOM	Gliders for Research Ocean Observation and Management
GSC	Genomic Standards Consortium
GTS	Global Telecommunications System
HAB	Harmful algal blooms
HELCOM	Baltic Marine Environment Protection Commission
HF	High frequency radar
IBI	Iberian Biscay Irish
ICES	International Council for the Exploration of the Sea
ICOS	Integrated Carbon Observation System
INSDC	International Nucleotide Sequence Database Collaboration
INSPIRE	Infrastructure for Spatial Information in Europe
IOC/INF	IOC Information Document
IOCCP	International Ocean Carbon Coordination Project
IODE	International Oceanographic Data and Information Exchange
IOOS	Integrated Ocean Observing System
IP	Intellectual property
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
IPR	Intellectual property rights
ISC	Innovation and Stakeholder Committee
ISTAB	International Scientific and Technical Advisory Board
IVZW	Internationale Vereniging Zonder Winstoogmerk
JCOMM	Joint Technical Commission for Oceanography and Marine Meteorology
JCOMM-OCG	JCOMM Observations Coordination Group
JCOMMOPS	JCOMM in-situ Observing Platform Support Centre
JPI	Joint programming initiatives
LTER	Long-Term Ecological Research
MEP	Members of the European Parliament
MFC	Monitoring Forecasting Centre
MGA	Model Grant Agreement
MONGOOS	Mediterranean Operational Network for the Global Ocean Observing System
MOOSE	Mediterranean Ocean Observing System for the Environment
MPA	Marine protected areas
MSFD	Marine Strategy Framework Directive
MSP	Maritime Spatial Planning
NRT	Near real-time
OA	Open Access
OBIS	Ocean Biogeographic Information System
OBPS	Ocean Best Practice System
OECD	Organisation for Economic Co-operation and Development
OHC	Ocean Heat Content
OSNAP	Overturning in the Subpolar North Atlantic Programme
OSPAC	Oceanographic Services for Ports and Cities

OSSE	Observing System Simulation Experiment	SMEs	Small and medium-sized enterprises
OVIDE	Observatoire de la variabilité interannuelle et décennale en Atlantique Nord	SOCAT	Surface Ocean CO_2 Atlas
PCU	Project coordination unit	SOOP	Ships of Opportunity
PEST	Political, economic, socio-cultural and technological	SOP	Standard operating procedures
POGO	Partnership for Observation of the Global Ocean	SSC	Scientific Steering Committee
PSMSL	Permanent Service for Mean Sea Level	SST	Sea Surface Temperature
QC	Quality control	TAC	Thematic Assembly Centre
R&D	Research and Development	TAOS	Tropical Atlantic Observing System
REP	Reprocessed	TGTT	Tide Gauges Task Team
RIA	Research and Innovation action	TRL	Technology Readiness Levels
ROOS	Regional Operational Oceanographic System	TS	Time-series
RRI	Responsible Research and Innovation	UN	United Nations
RV	Research vessel	UNCLOS	UN Convention on the Law of the Sea
SC	Steering Committee	UNEP	UN Environment Programme
SCC	Social cost of carbon	UNESCO	UN Educational, Scientific and Cultural Organization
SCOR	Scientific Committee on Oceanic Research	UNFCCC	UN Framework Convention on Climate Change
SDG	Sustainable Development Goals	WFD	Water Framework Directive
SLA	Sea Level Anomalies	WGHANSA	ICES Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA)
SLADE	Sea Level Advice Demonstrator	WMOP	Mediterranean Operational forecasting system

1. Excellence

1.1 Objectives

The Ocean covers 70 % of the Earth's surface, and plays a critical role in providing the air we breathe and the freshwater we drink. The ocean makes our planet habitable as a primary controller of the global climate system. The Ocean is the pathway for 90 % of global trade and provides a wealth of resources supporting human livelihoods, with enormous economic impact. More than 50% of Europeans live in the coastal zone and many of our communities rely on the ocean for their livelihoods and well-being. A healthy and safe ocean provides food and essential recreational space. The impact of the ocean extends well beyond the coastal zone through its role in weather and climate and there is an urgent need to assess human pressures on the ocean, particularly in vulnerable coastal areas. Investors are increasingly looking towards the ocean for economic opportunities. OECD projections[1] suggest that the Ocean Economy, evaluated as 2.5% of the world economic value of goods and services produced, is expanding rapidly. By 2030, ocean industries have the potential to double in size, outperforming the global economy as a whole, and making an important contribution to blue growth and employment.

The Ocean is changing; it is heating up, acidifying and losing oxygen[2] as human induced pressures continue to increase. The ocean is increasingly coming under threat from increased pollution (including marine litter), fishing pressure, and deep sea mining, for instance. The Tsukuba Communiqué states[3]: *"The Ocean is changing, with some 30-35% of critical marine habitats having been overused or destroyed, ocean acidity having increased by 26%, and oxygen generally depleting in the coastal ocean. Indeed, the health of the ocean is such a crucial economic development issue that it has warranted an explicit UN sustainable development goal (SDG 14) to "conserve and sustainably use the oceans, seas and marine resources for sustainable development". Similarly, SDG 13 looking at Climate Action recognises the significant impacts of climate change which can lead to sea-level rise, decrease of sea*

[1] The Ocean Economy in 2030, OECD, http://dx.doi.org/10.1787/9789264251724-en

[2] Nicolas Gruber Warming up, turning sour, losing breath: ocean biogeochemistry under global change369Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, http://doi.org/10.1098/rsta.2011.0003

[3] Tsukuba Communique (Attachment 2 http://www.g8.utoronto.ca/science/2016-tsukuba2.html:

ice extent and thickness, changes in ecosystem productivity and biodiversity, extreme weather events and changing weather patterns which are all influenced by the oceans and seas." The UN Decade of Ocean Science for Sustainable Development recognizes that urgent actions are required to maintain a life-supporting ocean and ensure adequate protection and adaptive management of the marine environment.

There is an equally urgent need to better connect ocean observations to users in governments, communities and industry that need this information as the base for sound decisions and policies. Sustainable management of the ocean requires an ocean observing system that delivers fit-for-purpose information serving governments, societies, sustainable blue economy, and citizens, leading to better assessment of the state of the ocean and better forecast crucial for supporting sustained management of the ocean, including exploration, exploitation, and protection of the marine environment.

The ocean is vast and variable, making it an expensive place to operate, and is critically under-observed, especially in biological parameters. The challenge is to grow the systematic observations of the ocean including physical, chemical, biological, and ecological properties. The Tsukuba Communiqué clearly spells out the challenge: "*ocean observing is "big science". Proper, sustained, comprehensive and globally coordinated observation of the ocean and seafloor is necessary so that we have the tools to provide the data and understanding required to inform, with evidence, policy decisions about use of the ocean, especially against the background of human-induced change and natural variability*. *A comprehensive ocean observing programme would need to operate under a sound international framework in order to i) coordinate the deployment of global ocean observing assets to optimize their usage, ii) promote global data sharing and best enhance international access to data and data interoperability, iii) produce regular authoritative assessments of the state of the oceans and the ecosystems they contain*."

The ocean observing system consist of observing networks, integrating their data output in data assimilation centers that feeds into the assimilation and forecast systems. A wide range of platforms and systems constitute the current global ocean observing infrastructure, including satellite observations, research vessels, autonomous floats, underwater gliders, fixed-point observatories, sea level stations, high frequency radar and autonomous surface vehicles. Currently the ocean observing system remain largely immature and is composed of a large and diverse set of actors, such as research institutes, governmental agencies and the private sector. In particular there are gaps in sustained observations of biological variables; the Tsukuba Communiqué states "*Further innovation is necessary to provide a suite of sensors fully capable of capturing key biological processes, and consideration should be given for options to help facilitate ocean observations from the range of available observing platforms and systems*".

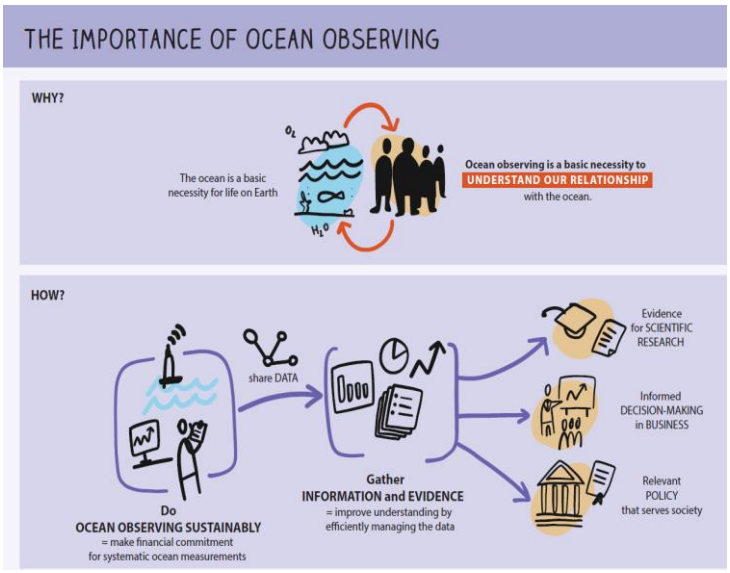


Figure 1: *The why and how of ocean observing, from the European Ocean Observing System (EOOS).*

The fragmentation of the observing system has led to suboptimal efficiency and ineffectiveness leading to gaps in ocean information. EuroSea will *integrate* existing ocean observation systems and tools, thereby bringing this newly coordinated system to TRL6 or higher. In addition, development of individual components (e.g. observing networks, sensors, forecasting systems) will bring them to TRL6. The framing of ocean observing in the Framework for Ocean Observing (FOO)[4] sets the scene and introduces the system thinking of ocean observing which EuroSea has adopted. EuroSea, consisting of key European actors of ocean observation and forecasting, galvanizes the European marine community to meet this challenge through developments in marine technology for ocean observations (e.g. instruments for sea level) and forecasting capabilities (e.g. for low pH events) through improved networks and sustained cooperation.

The **overall aim of EuroSea** is to significantly improve the European ocean observing system as an integrated entity within a global context, delivering ocean observations and forecasts to advance scientific knowledge about ocean

[4] A Framework for Ocean Observing. By the Task Team for an Integrated Framework for Sustained Ocean Observing, UNESCO 2012, IOC/INF-1284, doi: 10.5270/OceanObs09-FOO

climate, marine ecosystems, and their vulnerability to human impacts and to demonstrate the importance of the ocean to an economically viable and healthy society.

EuroSea will consider requirements for important end-users and stakeholders such as: governments and regulatory bodies (e.g. environmental agencies); intergovernmental frameworks (e.g. SDG14, UNFCCC, MSFD); fisheries, aquaculture; ocean energy; coastal and port managers; marine research; the public. EuroSea will optimize the observing system in a process of co-design and stakeholder dialogues. This will guide the design of three demonstration activities to provide exemplars of ocean observing systems for **operational services**, **ocean health**, and **climate** thereby supporting the development of the blue economy, provide increased safety and information about climate change and the effectiveness of climate mitigation strategies. EuroSea will lead to a strengthened European Ocean Observing System (EOOS) with support for the Global Ocean Observing System (GOOS) and Global Earth Observation System of Systems (GEOSS). EuroSea will work closely with existing marine data infrastructures to increase their capabilities and facilitate efficient data exchange and harmonization including adequate information on internationally agreed Essential Ocean Variables (EOVs)[5] across physics, biogeochemistry and biology / ecosystems, i.e. ocean variables with high feasibility (to observe) and high impact (on essential ocean information).

EuroSea will improve: 1) the design of the observing system adapted to European needs; 2) in-situ observing networks and data integration; 3) integration of remote and in-situ data; 4) the forecasting systems. This flagship initiative will enable a quantum leap in making the European ocean observing a better public utility and a key enabler for a sustainable blue economy in the long term. Ocean observing requires an international effort, and Europe should be a world leader, especially considering the significant investment to date in ocean observations by European states and the European Commission, and the level of expertise and know-how within the EU. In the absence of an initiative such as EuroSea, there is a real risk that Europe will suffer from inadequate ocean services, lack of vital ocean information, and loss of leadership in ocean science, technology and the blue economy. This will have considerable consequences, resulting in unsustainable ocean management and risk of environmental, social and economic damage.

To achieve this EuroSea has **7 innovation action objectives:**

1. To strengthen European **leadership** in Ocean Observing System **coordination** and **foresight** at an **international** level; in particular strengthening the European Ocean Observing System (**EOOS**) and contributing to the implementation of the Global Ocean Observing System (**GOOS**) 2030 **Strategy**. [**WP1,3,6**].
2. To provide a refined **system design** in support of an integrated European Ocean **Observing and Forecasting** system for the European seas and the Atlantic, including the deep sea [**WP2,3,6**].
3. To improve and enhance the readiness and **integration of observing networks**, including thematic networks (**augmented observatories**) by supporting coordination and increasing the TRL of observing systems and tools and data delivery/management [**WP3,5,6,7**].
4. To enable **FAIR** data and facilitate integration of data by improving the data management structure and practices of the observing networks, and supporting ingestion of ocean data in the Copernicus Marine Service, EMODnet and SeaDataNet portfolios [**WP3,4,6**].
5. To deliver improved **assimilation and forecast products** from the ocean observing system by integrating EuroSea observations in Copernicus Marine Service monitoring and forecasting centers and developing new hybrid models that will assess uncertainties in forecast, and by developing new **EOV synthesis products** [**WP4**].
6. To **demonstrate** Ocean Observing methods and technologies and their integration in existing systems in support of; **operational services** (e.g. coastal resilience, beach safety, sea-state forecast), **ocean health** (e.g. water quality assessments, food security/safety, extreme event forecasts), **climate** (e.g. carbon audit, climate indicators) that are used for multiple purposes by different stakeholders (e.g. port operators, fishery, aquaculture, climate assessments) by developing novel ocean observing systems [**WP5,6,7**].
7. To create an **integrated, sustainable and fit-for-purpose** ocean observing system by engaging with a range of stakeholders through advocacy, dissemination and capacity building; supporting the blue economy. [**WP5,6,7,8**].

1.2 Relation to the work program

The aim of EuroSea is to build an interdisciplinary ocean observing system that delivers the essential ocean information needed for the wellbeing, blue growth and sustainable management of the ocean, which is aligned with the Call Challenge.

[5] http://www.goosocean.org/eov

EuroSea addresses the Scope of the BG7[B] call:

Actions shall demonstrate integration, capacity and (scientific, economic etc) potential.

EuroSea will improve and integrate observing networks and the data flow (**Obj.3,4, WP3**). EuroSea reflects the interdisciplinary and cross-sectoral nature of the ocean observing system, and support the capacity building to empower strategic partnership and business development (**Obj.6**) and will communicate achievements (**Obj.7**). This will support the blue economy, particularly in the demonstration activities (**WP5,6,7**) where the integrated ocean observing system is executed in an operational environment.

Projects shall complement and build on existing observation tools and systems such as EuroGOOS/EOOS, IOOS, GEO/GEOSS, COPERNICUS Marine Service or EMODnet, European research infrastructures such as Euro-Argo ERIC and EMSO ERIC as well as funded H2020 projects such as SeaDataCloud.

EuroSea will build on all of those programs (**Obj.1,3,4, WP1,3,4**) in order to provide a **sustainable** ocean observing system as a central theme. For instance, the GOOS biogeochemistry (BGC) panel will build a coordinated observing network for marine litter, **T1.1.1** will actively support the development of EOOS, **T3.4** will improve European fixed-point observing systems through EMSO-ERIC, and **WP4** will support Copernicus Marine Service to ingest ocean data from new networks, 1.3.3 for details.

The interdisciplinary and cross-sectorial nature of the proposal should also apply to training activities improving the professional skills and competencies of workers and supporting the creation of new jobs in the blue economy.

EuroSea will improve best practices documentation to disseminate knowledge, and specific training activities for the ocean observing value chain will be implemented by the demonstration activities (**WP3,5,6,7,8**), including third country actors, and by Networks in **WP3**. Training will include network or sensor specific training (**WP3,5,6**), and training on observation system functionality (**WP5,6**).

The action shall contribute to the development and demonstration of the feasibility of the European component of a future Global Ocean Observing System in line with the G7 Tsukuba Communiqué.

This is the overarching objective of EuroSea, where the components of the ocean observing value chain are improved in **WPs 1, 2, 3, 4, and 8** with the aim of increasing the TRL for the whole observing system (aiming for at least 6) as well as for components such as observing networks, sensors, forecast systems etc. EuroSea will contribute to the development of the European component of a future Global Ocean Observing System by strengthened EOOS (**All Objectives**). The feasibility of the observing system will be demonstrated in the three demonstration activities (**WP5,6,7**).

It will support activities in the different EU sea basins and the Atlantic Ocean, including the deep sea (below 2000 m), also supporting the needs of food security and safety as outlined in Food 2030

EuroSea will improve observing networks (**WP3**) implementing ocean observations in EU basins (North Sea, Baltic, Mediterranean, and Atlantic) including the deep sea (deep Argo, RVs). EuroSea will improve the marine omics observing capacities (**WP3**) to utilize that potential (**Obj.6**). EuroSea will incorporate marine elements of Nutrition and Health Challenges by implementing tools to design new management strategies aimed at sustainable management of small pelagic fish (**WP6**). EuroSea will co-design the design of the observational system with the aquaculture sector to provide support for increasing the availability of seafood by providing early warning for extreme marine events (low oxygen, pH or heatwaves) episodes that can have detrimental effect on aquacultures; early warning provide a potential for the operators to deploy mitigation measures. For instance, EuroSea are working with Mowi, Ireland, toward building and sustaining two new in situ observatories in the NE Atlantic where Mowi will provide in-kind contributions relating to access to on-site fish farm facilities and staff-time, expertise and feedback to assist in EuroSea activities. EuroSea will provide maintenance training and support to ensure Mowi can sustain the system into the future.

It will also support the future Collaborative Research Action on Oceans of the Belmont Forum and the International Ocean Governance Communication

EuroSea will consider governance systems for the observing system within the legal frameworks (e.g. UNCLOS, UNFCCC, CBD) that exists and are important for countries conducting ocean observing activities, or for which it would be relevant to develop ocean information products. EuroSea will analyze frameworks and mechanisms (e.g. National Adaptation Plan process) to enable adequate adaptation of ocean observing system design at a regional and global level, with a focus on supporting sustained ocean observing and fit-for-purpose ocean information (**WP1**). EuroSea will provide ocean data and information needed for support of the actions in these documents; 11 (of 14) actions in the joint communication will be directly addressed by EuroSea (**WP1-8**). EuroSea is strongly supporting international cooperation and integration of the ocean observing system, for instance by cooperation with, and support of, organizations like EOOS, GOOS,

JCOMM and OceanPredict (**WP1**). International coordination is key to improve the efficiency of the observing system, promising high return on investment.

It will underpin forecasting of the state of the ocean, climate change impact and weather.

EuroSea will improve forecast systems directly in **WP4** by improving the operational design of the observing system (**WP2**), which are implemented in the three demonstration activities (**WP4,5,6,7, Obj6**). Forecasting products are the central objective of **WP5** for coastal resilience and for **WP6** on extreme marine events. A focus that EuroSea will be addressing is on downscaling of the forecast for local ports, coastal cities and aquaculture, for instance (**WP4,5,6**). Additional efforts will be to improve forecasting capability for biogeochemical variables, such as oxygen and carbon / pH (**WP4,6**), and improvements in forecasting by including data from more observing networks, e.g. gliders and autonomous surface vehicles (ASVs). Efforts will be made improve visualization tools to increase the utility for end users.

Activities shall include the demonstration of methods and technologies and their integration in existing systems to collect information on the state and variability of European seas and the Atlantic Ocean, including the impact of stressors and marine litter, and underpin sustainable management of the marine environment and its resources

Eurosea has three demonstration activities tasked with demonstrating the utility of the observing system for operational services ocean health and climate (**WP5,6,7**). These are centrally positioned in the project and will be supported in their activities by **WP1,2,3,4,8,9**. Two of the demos focus on local processes directly aimed at local end users (operational services and health, **WP5,6**) whereas the climate demonstration focus on open ocean regions in the Western Mediterranean Sea, Northwest Subpolar Atlantic and the tropical Atlantic, all areas with particular large carbon fluxes (**WP7**). The stressors heatwaves, ocean acidification and low oxygen concentrations are directly addressed. EuroSea will develop capacity and coordination for sustained ocean observations of marine plastic contaminants by establishing a common sampling protocol and support implementation among European observing network partners.

They shall take account of the needs deriving from the G7 Future of the Seas and Oceans Initiative, from actions such as the Atlantic Ocean Research Alliance and its related South Atlantic Flagship, the BLUEMED Initiative, and notably common priorities with the WestMED Initiative and the EUSAIR, and actions addressing other European regional seas.

EuroSea as whole is directly responding to the needs from the G7 WG, see above. EuroSea is integrating observing capacity in the North Atlantic (**WP7**) in close cooperation with partners in Canada, aligned with the Galway agreement, to improve the observing system in the North Atlantic for better quantify the impact on climate (carbon storage and flux, heat content). We will work close with partners Brazil, utilizing the station on Cape Verde, to improve the observing system in the tropical Atlantic, aligned with the Belém agreement, to produce climate related ocean indices and information. EuroSea aims at improving large-scale and local forecasting in the Mediterranean, e.g. port services in Barcelona, Taranto and Alexandria (**WP5**), and provide forecasting for extreme events in the Alboran Sea (**WP6**), supporting local maritime economy. EuroSea will assess the effect of the Western Med for its role in climate, i.e. carbon and heat uptake (**WP7**).

The inclusion of forecasting tools (for example to protect aquaculture installations or to inform fisheries decision making) shall be an advantage.

EuroSea will underpin the ocean and atmospheric forecasting systems for deliverable of more accurate seamless predictions (**Obj.5**). EuroSea will merge oceanographic observations with observations and products from fishery and environmental agencies (e.g. HELCOM, ICES), in order to develop management strategies able to minimize the biological and economic vulnerabilities in stock dynamics of small pelagic fish as forced by the physical environment. EuroSea will develop forecasting tools and capacity to inform stakeholders such as aquaculture and fishery on extreme marine events with potentially damaging effect on ecosystem and business (**WP6**). EuroSea will develop forecasting tools supplying oceanographic services (e.g. water quality, navigation safety, beach safety, and sea state) for ports and cities (**WP5**).

The sustainability of the approach selected, the integration of innovative observations solutions and existing systems, the smooth storage of data in open access data centers and the improvement of the predictive capability shall be demonstrated.

EuroSea will actively engage with stakeholders, both users of ocean observations as well as the observing community, to foster and develop a stakeholder dialogue for co-design of the observing system, and to build advocacy for the ocean observing system to a broad audience to ensure sustainability and growth of the ocean observing system (**WP8**). The three demonstration activities will show the integration of new and existing observations, through open data (FAIR principles) with the aim of producing forecasting products with direct benefit to end users. For instance, **WP6** is working with companies to ensure sustainability of the ocean observing solutions after the end of the project, see above.

Observations and data handling may also include pilots for Essential Ocean Variables (EOVs) under consideration (for example, nutrients, carbonate, sound and microbes/omics) and variables that are of importance in European regional seas as well as the integration of "augmented" observatories.

EurosSea will deliver on increasing the readiness level for the regular and sustained delivery on a range of EOVs measured by a range of observing networks (e.g. research vessels, Argo, gliders, ASVs) (**Obj.3**). WP7 will develop new methods to link data to improve delivery of ocean data (inorganic carbon – including pCO_2 and pH – oxygen, Particulate Organic Carbon) utilizing integration of data from different platforms (e.g. BGC Argo, RVs, and ASVs). These will be distributed in an open, free and timely manner for easy access by all users by improved ingesting of data from the networks to Copernicus Marine Environment Monitoring Service (CMEMS) and EMODnet, products with an acceptable level of metadata and homogeneous quality (**Obj.4**). EuroSea will contribute to measurements of more than half of the EOVs through a range of instruments and platforms in **WP5,6,7**. EuroSea will improve the capacity to measure biological diversity and biomass by the development of augmented observatories, utilizing state-of-art methodologies in genomic-enabled research at multidisciplinary observatories at well-established marine LTERs[6], including a mature oceanographic observatory in Naples (**WP3**).

Flow of information across variables and disciplines shall be included.

Integration of the ocean observing system is a central principle of EuroSea. For instance, EuroSea has two tasks focused on integration, one across observing networks (**T3.9**) and another one focused on integration of data (**T3.10**). **WP4** deals with the integration of EuroSea in-situ data with satellite data (in particular Sentinel missions) and models, e.g. gliders, HF radar and drifter observations will be used in addition to Argo and satellite data to derive estimates and forecast of temperature, salinity and surface velocities. The common theme of the three demonstration activities (**WP5,6,7**) is using multiple observing platforms taking measurements across disciplines to generate user-friendly information products. For instance, EuroSea support information flow relevant to fisheries and aquaculture that in addition to the economic value have important societal components for local communities (**WP6**). EuroSea will provide information on important climate indicators, including acidification (**WP7**).

Data collected shall be in line with agreed standards, be openly available via portals (including EMODnet) and feed into the Pilot Blue Cloud (part of the European Open Science Cloud).

Open and free data (FAIR data) is a key high-level priority and underpinning principle of EuroSea through the whole project (**WP3,4, Obj4**). A main objective is to ensure that EuroSea new or consolidated data sets (physics, biogeochemistry) will be ingested in the Copernicus Marine Service and EMODnet portfolios, feeding into the Pilot Blue Cloud. A task is **WP9**, supported by **T3.10**, is in charge of coordination and exchange with the activities in the Blue Cloud. A common theme of **WP3** is to improve the capacity for the networks to deliver data in line with agreed standards (that are often network specific), or, for the case that such standards are poorly defined, will support proper standard definition.

International cooperation with Third Country partners is encouraged.

EuroSea includes 4 participating organizations from Brazil and Canada (ERJ, UFPE, MUN, DAL) for cooperation on implementing the demonstration activity in the northwest and tropical Atlantic (**WP7**) focusing on delivery of biogeochemical and physical information relevant for climate and ocean health. Long standing cooperation with these partners already exist, that will be strengthened during the project. For instance, the Canadian partners have initiated projects looking at the carbon uptake in the Labrador Sea – the efforts of EuroSea will link to, and complement, those activities. Close cooperation with African countries (e.g. Egypt) is planned for the demonstration activity on coastal resilience (**WP5**), executed by a co-development process and installation of the necessary equipment and software (OSPAC, **WP5**). This will be complimented by a capacity building activity in order to provide sustainability to the system, by supporting visits of local technicians to acquire appropriate skills for the installation and maintenance.

Proposals shall include a task to cluster with other projects financed under this topic and – if possible – with other relevant projects in the field funded by Horizon 2020.

EuroSea has a task to cluster with these projects on a strategic level (**T9.2**) and on an operational level by **WP3**. This include current projects like Eurofleets+, AtlantOS and ODYSSEA, and project to be funded under the BG7[A] and [C] calls, as well as LC-BG-09-2019.

Cross-cutting priorities of EuroSea is to support the implementation of an European *integrated* ocean observing system by increasing the TRL of coordination and governance, system design, observing networks, data delivery

[6] Long Term Ecosystem Research, http://www.lter-europe.net/

and output (e.g. forecasts, assessments). The complete value chain will be demonstrated in **WP5,6,7** through a co-design process with end-users and the operators of the observing system.

1.3 Concept and methodology

1.3.1. Overall concept underpinning the project.

Improving ocean observation and forecasting capacity is vital to: 1) understand and improve forecasting of global and regional-scale change and variability; 2) manage and sustain the productive capacity and resilience of the Ocean's ecosystems under an ever increasing pressure from human activities; 3) minimize human impacts by sustainably harvesting renewable marine resources and responsibly exploiting finite marine resources; 4) provide an observational basis for scientific discoveries; and 5) strengthen partnerships and governance structures that provide timely and fit-for-purpose ocean information that supports sustainable ocean management.

Our capacity to effectively manage Ocean resources is limited by fundamental gaps in the current observation efforts and forecasting skills. These gaps mainly consists of: 1) insufficient coordination and governance at national, European and international levels; 2) ineffective observing design, individual networks are designed for a particular purpose, but insufficient designed for a system consisting of a variety of networks for a range of users; 3) varying degree of observing network maturity in terms of best practices, technical coordination, standards etc.; 4) incomplete uptake of ocean observations (i.e. missing networks) by ocean assimilation and forecast systems. In addition, for almost all parts of the observing system technical improvements have potential to revolutionize the observing system, but additional efforts are needed. As ~60 % of the Ocean is beyond national jurisdictions, monitoring, managing and safeguarding ocean resource is a European and international issue that cannot be accomplished by any one nation alone. Many of the observing and forecasting system elements are already in place, and significant gaps can be overcome by integration of individual elements to a well-working system, increasing resources where needed. EuroSea brings key actors of ocean observation (e.g. research institutes, agencies, data centers, private entities) together with key users of ocean observations (e.g. the scientific community, agencies, blue economy actors such as fisheries and aquaculture) to a consortium with unprecedented potential to design and demonstrate better observing systems and tools.

EuroSea will contribute towards a design for a European fit-for-purpose sustained ocean observing system providing information for a range of users, e.g. the EOOS strategy[7]. The whole value chain for ocean observations will be considered from increased readiness of the in-situ observing systems (e.g. the observing networks), increased integration with satellite data, to improved data management systems feeding data aggregation and data assimilation systems. EuroSea will enable integration of individual observing elements and support international coordination of the observing system as a whole, and will integrate end-users and information providers with the operators of the observing system. The demonstration activities are a central component of EuroSea; these will be aiming at validation of the ocean observing value chain including market replication of end-user services (**WP5,6,7**) by integrating all components of the observing system addressed by EuroSea. The demonstration activities will be supported by all WPs in EuroSea to optimize effectiveness, integration and feedback, and will highlight the value of ocean observing. We have chosen three general themes for the demonstration activities: *operational services, ocean health and climate*. These are the three societal benefit areas targeted by GOOS. EuroSea will extend the scope of existing European ocean observing networks and integrate across disciplines (*physics, biogeochemistry, biology and ecosystem*, thereby utilizing progress in engineering, IT, data processing, modelling etc. The integration aspect is critical due to the interdisciplinary nature of the challenges facing the ocean today where collaborative efforts are essential. Significant synergies and increased efficiency of the system that can be achieved through international and interdisciplinary cooperation, also between different agencies and institutions engaged in ocean observations, providing a means of better utilization of limited resources.

Our vision is a truly interdisciplinary ocean observing system that delivers the essential ocean information needed for the wellbeing, blue growth and sustainable management of the ocean.

This effort builds on, and complements, existing elements of the ocean observing system, such as EuroGOOS, GOOS, the GEO Blue Planet, the Copernicus Marine Service, EMODnet and EOOS. EuroSea will improve and strengthen the European component of an integrated international ocean observing system by increasing the readiness level of essential components of the ocean observing value chain, Figure 2.

[7] http://www.eoos-ocean.eu/strategy-and-implementation/

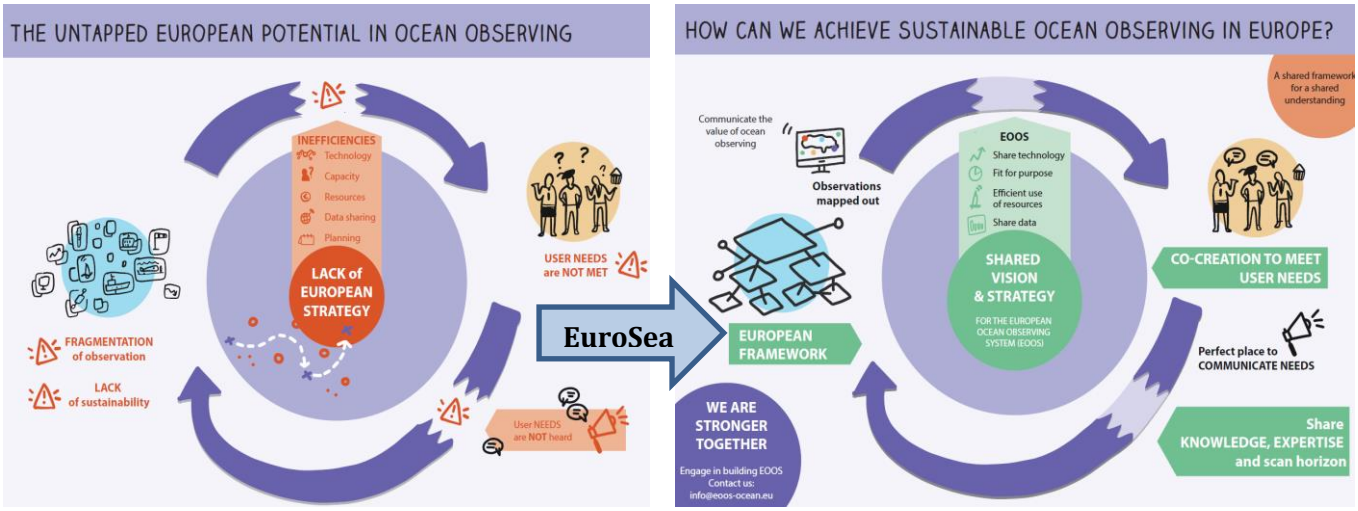


Figure 2*: The EuroSea vision: Moving from a fragmented dispersed ocean observing efforts (left), to that of a coordinated European Observing System framework (right). From the EOOS strategy*[8].

1.3.2 Positioning of the project in terms of technology readiness level (TRL)

The last few decades have seen significant innovation in ocean observing capacity in terms of innovative sensors and observing platforms, including biogeochemical and biological sensors, and autonomous platforms. These innovations have great capacity to improve the ocean observing system with several of the sensors and platforms already at TRL6, or higher. **On a system level, however, there is a lower TRL**. This is in part due to lower TRL at observing network level; for instance lack of best practices, community agreed meta-data and data standards, or lack of network technical coordination - hampering efficient data delivery from an uncoordinated system. Although the TRL is higher for some networks (e.g. Argo, GO-SHIP) than others; EuroSea will strengthen and increase the TRL of observing Networks focused around observing platforms that are considered under EuroGOOS and GOOS as well as emerging networks and thematic networks. This includes Argo (including BGC and deep Argo), underwater gliders, Research Vessels, Fixed-point observatories, GLOSS (Sea level gauges), HF Radar. Two emerging networks - augmented observatories (i.e. genomic-enabled multidisciplinary observatories) and ASVs will be supported to move to TRL5 considering the great potential of the new technologies but relatively immature network characteristics (immature level of technical coordination, best practices, data and metadata standards etc., see WP3). Generally, **EuroSea utilizes instruments and platforms with mature characteristics** and increase the ocean observing system efficiency by integration of individual observing elements (e.g. a sensor on a glider) to a mature observing network. Most networks are designed to deliver towards certain issues aimed at particular stakeholders, but there is **low level of integration between networks, delivering towards a wider range of users**. EuroSea will increase the TRL of the ***integration*** of observations and data from the different networks (**WP3**). Ocean data assimilation and forecast systems are less mature than, for instance those for meteorology; EuroSea will increase the TRL of information delivery through **improved methods and coordination of data assimilation and forecast systems**. EuroSea will promote innovation and methods for identification, documentation and exploitation of innovative observing systems by adopting a Strategy for Knowledge and Innovation Management that encapsulates the guiding principles of Horizon 2020.

Figure 3: *GOOS view of ocean observing networks.*

[8] http://www.eoos-ocean.eu/strategy-and-implementation/

EuroSea will also ensure that new or consolidated in-situ observation data sets from the different networks and the demonstrator projects in EuroSea are integrated in the European modeling and forecasting systems at different space and time scales, from the Copernicus Marine Service global to the regional North East Atlantic and Mediterranean Sea systems. This will increase the TRL, and skill, of the modelling and forecasting systems for **integrating in-situ and satellite observations**. EuroSea will increase the TRL to 7 for two existing delayed mode biogeochemical data products (i.e. SOCAT and GLODAP) by creating automated quality control and data ingestion processes and will initiate a project to create a data product of ship-based time-series, which is currently a gap. A key component in EuroSea consists of three demonstrator projects that are utilizing observing concepts for operational services, ocean health and climate using an integrative system to increase the delivery of information to stakeholders to TRL6.

1.3.3. European and international innovation activities linked to the project

EuroSea will bring together several networks, initiatives, organizations and innovation activities on a national, European and international level.

Links to the G7 Future of the Seas and oceans Working Group: EuroSea is drawing from, and implementing, action items identified by the G7 WG, in particular Action areas 1 and 4. EuroSea as a whole is responding to the Tsukuba Communiqué "*Support the development of an initiative for enhanced global sea and ocean observation required to monitor inter alia climate change and marine biodiversity, e.g. through the Global Argo Network and other observation platforms, while fully sustaining and coordinating with ongoing observation*". Three of the WP leads of EuroSea have been involved in the G7 WG meetings and activities for UK, Germany and France.

Links to AtlantOS (H2020): The AtlantOS project and the associated efforts to produce a Blueprint for Atlantic Ocean Observing is providing essential input into EuroSea in almost all aspects of this proposal. The AtlantOS initiative will have a long-lasting and sustainable contribution to the societal, economic and scientific benefit arising from this integrated approach. EuroSea has been be guided by the principle and guidelines outlined in the Blueprint vision document in its design phase and will be guided by the implementation document during the project - several of the participants are playing an active role in the Blueprint process.

Links to other H2020 initiatives: EuroSea will actively coordinate activities and strategies with other regional ocean observing flagships in this Blue Growth Call by targeted exchange activities such as reciprocal reporting at relevant meetings. This includes BG-08-2018-2019: All Atlantic Ocean Research Alliance Flagship, LC-BG-09-2019: Coordination of marine and maritime research and innovation in the Black Sea, as well as to BG-01-2018: Towards a Baltic and North Sea research and innovation program, BG-05-2019: Multi-use of the marine space, offshore and near-shore. EuroSea will also link to the two other calls in this topic on Blue Cloud Services (BG7A) and Technologies for observations (BG7C). At a strategic level, this will be done by a task in **WP9** by exchange of strategies and ides, and on an operational level by **WP3** by supplying data, interaction on observing network level and exchange of experience and result from the demonstration activities.

Links to Copernicus Marine Service and EMODnet: EMODnet and the Copernicus Marine Service will be kept closely coordinated with and integrated into several of the EuroSea activities. We will ensure a real-time and delayed mode data flow from EuroSea networks and demonstrator projects towards EMODnet and the Copernicus Marine Service. The Copernicus Marine Service will benefit from the upgraded data information flow for ocean analysis (**WP3**) and improved forecast models developed in **WP4,5,6** and will be an integrated part of EuroSea. The impact of in situ networks for the Copernicus Marine Service will be quantified. The new ocean information products from EuroSea will make use of the products and services from the Copernicus Marine Service (forecasts, reanalysis etc.) to showcase the importance of ocean observing for all GOOS societal benefit areas.

Links to EuroGOOS: EuroSea will work with EuroGOOS on improving networks and forecast products (**WP3,4**) towards an integrated, sustained and fit-for-purpose European ocean observing system, underpinning the EOOS framework. EuroGOOS is a partner of EuroSea and the integration of observations, information delivery and dissemination will be co-produced by EuroSea and EuroGOOS. EuroGOOS is a partner of EuroSea represented by Glenn Nolan (WP1 co-lead, EuroGOOS director) and Dina Eparkhina (WP8 co-lead).

Links to EMB: The European Marine Board (EMB) is the leading European think tank in marine science policy and as such provides a platform to advance marine research and to bridge the gap between science and policy. EMB is a partner in EuroSea that will support foresight and be an important partner for the co-design of the observing system through stakeholder dialogues (**WP1,8**). Sheila Heymans is leading T1.4 and is director of EMB.

Links to EOOS: The European Ocean Observing System, EOOS, is a community-driven coordinating framework for Europe's ocean observing capacity. EOOS will help linking the disparate components of the ocean observing system and promote shared strategies, infrastructure development, data standardization, open access, and capacity building. EuroSea will be engaged in building and supporting the EOOS framework, led by **WP1** on a strategic level and supported by **WP2,3,4** on an operational level. Although EOOS do not have an office, the two funding

organizations of EOOS are both represented in EuroSea by Glenn Nolan (WP1 co-lead) and Dina Eparkhina (WP8 co-lead) from EuroGOOS, and Sheila Heymans (T1.3, 1.4 lead) from EMB.

Links to GOOS: The Global Ocean Observing System vision is a fully integrated global ocean observing system that delivers the essential information needed for our sustainable development, safety, wellbeing and prosperity. GOOS is a partner of EuroSea and will provide the important context and link between EuroSea and the international community around ocean observations and the connection to the observing community at large (**WP1**). GOOS is a partner of EuroSea (through IOC-UNESCO), represented by Emma Heslop (co-lead of WP1) and Toste Tanhua (co-chair of GOOS, and the EuroSea coordinator and WP9 lead).

Other international research and innovation activities linked to EuroSea: In addition to the programs and initiatives mentioned above, there are strong links to other projects and programs in Europe and internationally. On an international overarching level there are strong links to **GEO, GEOSS, GEO BluePlanet, and GODAE Ocean View** (Ocean Predict) linking earth observations from space with in-situ data and ocean assimilation and forecasting (**WP1,4**). We are closely tied to the goals of the Global Climate Observing System **(GCOS)**, particularly through **WP7** and the climate indicators and delivery of climate relevant ocean information. EuroSea is closely linked to the efforts by **JCOMM**, the Joint Technical Commission for Oceanography and Marine Meteorology of IOC/UNESCO and WMO, particularly through the operational monitoring and network support by **JCOMMOPS** and the JCOMM Observations Coordination Group (**OCG**) through **WP1,3**. We are aware of efforts to restructure WMO and JCOMM, and will interact with relevant new initiatives and structures as they are formed. EuroSea further recognizes the efforts by the GOOS expert panels that play a fundamental role in requirement setting, providing scientific guidance to the observing community and by leading the community in the EOV process (**WP1,2**). EuroSea also links up to **GESAMP** (Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection) and UN Environment particularly around developing capacity for sustained observations of marine plastics (**WP1**). EuroSea will also support the thematic network focused around advances in molecular methods such as genomic and transcriptomic approaches (**GLOBICOM**) through T3.9 and the global ocean acidification observing network (**GOA-ON**) through WP6 and7.

Through the proposed cross-sectoral engagement, EuroSea will establish multi-stakeholder partnerships focused on the use of marine scientific knowledge to support policy action to conserve and sustainably use the oceans, seas and marine resources (**SDG14**). The outcomes of EuroSea will provide and demonstrate the machinery needed to monitor, manage and deliver all six societal outcomes of the UN Decade of Ocean Science for Sustainable Development: A clean ocean (**WP2,3,5,6**); A healthy and resilient ocean (**all WPs**); A predicted ocean (**WP4,5,6,7**); A safe ocean (**WP4,5,6**); A sustainably harvested and productive ocean (**WP1,2,3,6**); A transparent and accessible ocean (**WP1,2,7**).

EuroSea will build on and complement ocean observing investments made by European countries either as national level or through European research infrastructures (e.g. Euro-Argo, EMSO, and ICOS). It will take advantage of recent initiatives. For instance, in January 2019, the Irish State announced, a proposed investment of *€2.04 Million* to purchase new ocean observing infrastructure that will be used to enhance Ireland's contribution to the European Ocean Observing system. It is envisaged that the new infrastructure will be made available to the EuroSea project (**WP6**). The observational component of EuroSea **WP7** will also benefit from the G7 partner Canada recent announcement of investment of up to *5.6 million Cd$* in Argo floats for the Canadian Waters and the Labrador Sea. EuroGOOS will work with partners in Brazil that are operating the PIRATA array in the tropical Atlantic together with France and the US, and improve the system in particularly for biogeochemistry and a pilot using ASVs. The ASV missions will be launched from Ocean Science Center Mindelo (OSCM), a cooperation between GEOMAR and the INDP (Instituto Nacional de Desenvolvimento das Pescas). OSCM will provide logistical support and GEOMAR will provide an ASV.

1.3.4 Overall approach and methodology

We have a very strong partnership gathering key European and international actors involved in ocean observing and forecasting in the Atlantic and European Seas, containing national research institutions as well as European and international organizations (e.g. IOC/UNESCO, EuroGOOS, EOOS, GOOS, ECMWF). The project is organized around, and guided by, the concepts laid out in the Framework for Ocean Observing (FOO). In the core of EuroSea, we have placed **demonstrator activities** focused on the three societal relevant areas of **operational services, ocean health and climate**. The demonstrator projects **(WP5,6,7**) apply the full value chain of ocean observing, from stakeholder dialogue through design, observations, open and free data, integration of data for forecasting for improved predictability. In doing so the demonstrator projects draws from **WP1,2,3,4,8** (Figure 4) that all are tasked with supporting the demonstrator projects.

WP1 "Governance and coordination of ocean observing and forecasting systems" will strengthen the interactions between regional, national and international observing systems, and support the development of a

European coordinated system through EOOS. The task will in particular support the international coordination for biological and ecosystem ocean observations, critically needed to improve information delivery on bio/eco and BGC EOVs. EuroSea will improve BioEco networks throughout the European Seas, including data flow and best practices, support the requirement setting of ocean observing particularly around biological/ecosystem essential ocean variables (EOVs) and for the emerging EOV on human impact initially focusing on the problem of marine plastic litter. A critically important component of an efficient ocean observing system is coherent use best practices; WP1 will improve discovery and access to best practices. WP1 will also facilitate knowledge transfer and explore synergy on data assimilation and marine ecosystem analysis by linking with OceanPredict. WP1 will support the operational tracking of ocean observing networks, and provide foresight on ocean observing; drivers, capabilities and latest scientific knowledge and the technological feasibility. EuroSea will provide an analysis on governance of the observing system and the relevant law frameworks (e.g. UNCLOS, UNFCCC, CBD) and mechanisms (e.g. National Adaptation Plan process) focusing on sustained ocean observing and fit-for-purpose ocean information products.

WP2 "Ocean Observing System Design" will focus on verifying EOVs and indicators, analyzing the gaps of existing systems and possible upgrades. This WP will provide a refined scientific system design for the EuroSea observing system in support of connected and integrated European Ocean Observing and Forecasting systems to maximize the impact of the system and for creating synergies between observing elements by applying the systems thinking. WP2 will also improving the design of multi-platform observations for validation of high-resolution satellite observations with the aim of optimizing the utility of these observing platforms.

WP3 "Network Integration and Improvements" will improve and strengthen observing networks for its optimal use. WP3 will target observing network innovations and oversee key aspects of integration of observing technology for observing networks towards higher TRL and efficient data delivery. WP3 will improve network coordination by scientific/engineering expertise supported by a technical coordinator, and will improve Best Practice documentation and data quality control and dissemination capacity. WP3 will increase the integration between networks, towards an integrated ocean observing system. The observing networks targeted by WP3 are: Argo (including DEEP ad BGC extensions), underwater gliders, research vessels, eulerian observations, sea level, HF radar, and autonomous surface vehicles. WP3 will develop and implement a set of standard operating procedures for long-term omic observation aligned to the GOOS EOVs (e.g. microbial biomass and diversity) to augment well-established marine LTERs to become "augmented observatories". WP3 will also improve the integration of data from different networks and ensure that EuroSea new or consolidated data sets (physics, biogeochemistry) will be ingested in the Copernicus Marine Service and EMODnet portfolios.

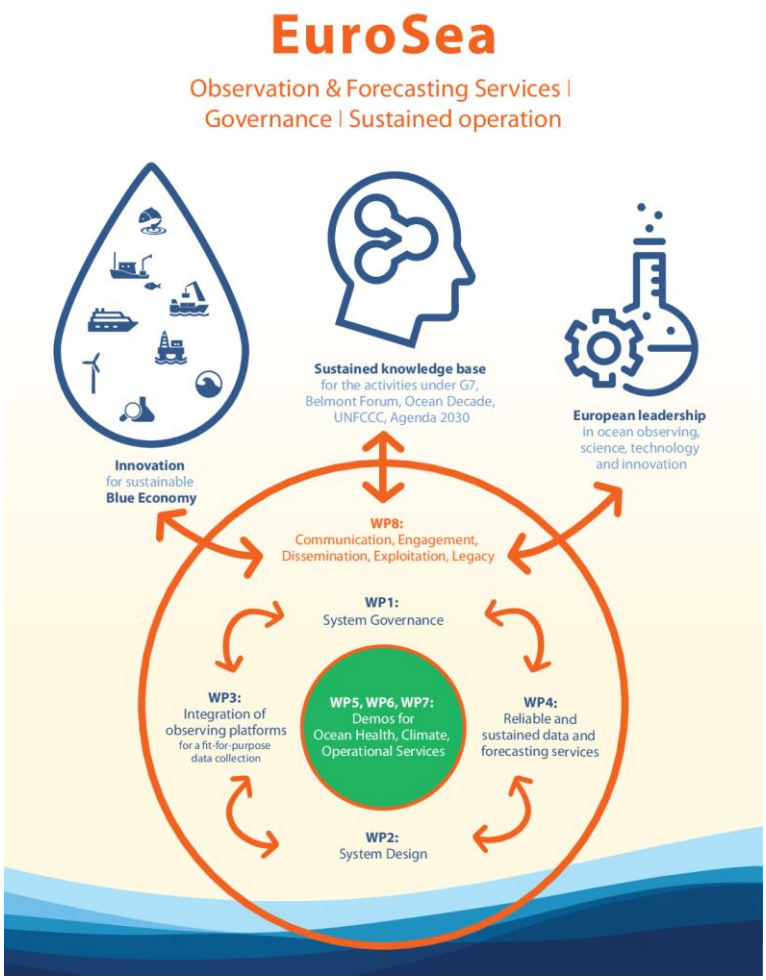
WP4 "Data integration, assimilation and forecasting" will integrate all observational datasets from EuroSea into the European modeling and forecasting systems, from the global Copernicus Marine Service to the regional North East Atlantic and Mediterranean Sea systems. These consolidated in-situ observation data sets will be ingested in the European modeling and forecasting systems at different space and time scales. Ensemble forecasting at regional level will be implemented specifically to extract Extreme Forecast Indices. Finally, the skill of ocean variables from the Copernicus Climate Change seasonal forecasting systems will be assessed using observables ECVs to develop and provide user-relevant indicators. All new products, observational and model data, will be integrated in the Copernicus Marine Environment Monitoring Service and the Copernicus Climate Change System thus reaching TRL7 and 8.

WP5 "Coastal resilience and operational services demonstrator" will make significant advances in the collection, quality control, interpretation and use of sea level data leading to new sea level and climate services by developing a consistent approach for combining sparse tide gauge data with satellite altimetry in order to deliver a spatially complete picture of sea level changes. This WP will create an integrated set of tools and measuring instruments that will provide an operational service to the city and the adjacent port in order to minimize risks and improve environmental management. High-resolution operational forecast systems for wave, sea level, sea surface temperature, and circulation will be developed at all test sites. WP5 will prototype a multi-parametric monitoring station, model the interactions between sea level hazards, economic activity and risk by developing prototype scenario planning and visualization tools, an implement these at the pilot sites in Barcelona, Taranto and Alexandria.

WP6 "Ocean Health Demonstrator" will develop a shared understanding of water management among end-users in Aquaculture, Fisheries, Tourism, Environmental Agencies and Scientists by working together to co-create products that help to identify and foresee "*Extreme Marine Events*" (i.e. low pH or oxygen levels and marine heat waves), and supporting adaptive management decisions. Extreme marine events are threatening marine ecosystems, resources, food security and related businesses. This will be achieved by demonstrating the value of ocean observing and forecasting of "Extreme Marine Events" at local to regional scales by developing downstream products and services to assess marine ecosystem health that provide an early warning system to support sustainable Blue Growth industries and food security needs. This will support the sustainable development of ocean observing and forecasting systems to monitor ocean health by stimulating international ocean observing initiative, and has the potential to create new market and management opportunities for the private sector. The novel focus on Extreme Marine Events reflects an

enhanced engagement with issues of great concern to fisheries operators and marine environmental managers. WP6 will provide initial maps of Extreme Marine Events, integrate those with existing monitoring programs, and deliver forecast products. WP6 will facilitate science-stakeholder engagement focused on Atlantic Sargassum biohazard forecasting and monitoring and will connect the CMEMS and ICES communities to assess existing products improving scientific advice to fishery managers. WP6 will also integrate the Baltic Operational Oceanographic System (BOOS) and the Baltic Marine Environment Protection Commission (HELCOM) monitoring network for a better operational oceanography system and enhanced environmental assessments in the Baltic Sea.

WP7 "Ocean climate indicators demonstrator" designs innovative ways to assess the role of the oceans and seas in Earth climate through new ocean climate indicators that will be determined through collaboration with WP2,4 and verified based on performance.WP7 will evaluate the economic value of the ocean carbon sink using a combined observing, integration, and dissemination approach. T7.1 is focusing on carbon fluxes and uptake in the northwest Atlantic (Labrador and Irminger Seas) and the western Mediterranean, two very important areas for carbon uptake. A mixture of observing technology is applied augmented by deployments of Deep-Argo floats from EuroSea to generate observable and user-relevant marine indicators. WP7 will develop information products linking ocean color surface data together with in situ data from autonomous platforms, such as BGC-Argo, moored instrumentation and long-range autonomous surface vehicles (ASVs) that will be deployed by WP7. ASVs equipped with instrumentation for high-quality carbon measurements will be sent out on a multi-month pilot mission to integrate carbon measurements, using Time-Series stations in the North (Cape Verde Ocean Observatory – CVOO) and South Atlantic (Fernando de Noronha Observatory – FNEO) for validation. An ocean color satellite-based bio-regionalization of the tropical Atlantic will be established. Biogeochemical linkages between surface physical and biogeochemical constraints and carbon surface fluxes will be established empirically through neural networks that will serve to estimate carbon fluxes for the tropical Atlantic.



EuroSea, and the demonstrator activities (**WP5,6,7**) in particular, are involving private companies in all parts of the observing system; 1) as instrument providers seeking to improve the products to be fit-for-purpose (e.g. Xylem in T6.4, Saildrone in T7.3); 2) as beneficiaries of the observing system (e.g. Mowi Ireland, Board Iascaigh Mhara, port of Barcelona etc.; 3) and as co-producers of the observations (e.g. MOI, Nologin). The demonstrators aim for sustainability of the system with commitments from actors to continue successful demonstrators after the end of EuroSea, ensuring sustainability of the system and feeding the blue economy. EuroSea aims to increase the TRL to level 7 – system prototype demonstration in operational environment - by focusing on instruments, platforms, data and assimilation / forecast system. EuroSea will showcase how European industry can contribute to, and benefit from a sustained ocean observing and forecasting system. This will be executed particularly through the demonstrator activities, but is a common theme through all WPs. EuroSea will facilitate co-development of the ocean observing system for more efficient ways to engage with users of ocean information and establish new ocean information products to support society for sustainable management of the ocean resources and fully realize the opportunities indicated in the Blue Growth strategy.

Figure 4: *The overall concept of EuroSea. The lower part of the diagram shows how WP1,2,3,4 are located in the ocean observing value chain, feeding into WP8 for communication, engagement, dissemination and exploitation. The 3 demonstration activities are positioned in the inner circle interacting and benefiting from the activities in WP1,2,3,4,8. The arrows from WP8 upward illustrate EuroSea impact.*

WP8 "Communication: Engagement, Dissemination, Exploitation, and Legacy" supports all EuroSea activities and will display EuroSea innovations and improve information to a range of users. To achieve sustained legacy WP8 will address the sustainability of the project's results and deliver input into ocean observation strategies. EuroSea is explicitly considering ethical and gender aspects of ocean observing and forecasting through a task on RRI and ethical principles, ecosystem and human health approach and governance and policy instruments. WP8 will enable exploitation of the project's results and products towards end-users and support product validation and market replication, and provide intellectual property rights and business development for EuroSea knowledge and technology transfer. WP8 will support capacity building to empower strategic partnerships and support business development to empower the blue economy. This WP is also tasked with the project's legacy to ensure the outcomes inform relevant political agendas deliver advice on RRI guiding principles, best practice in knowledge and technology transfer,

1.3.5 How sex and gender analysis is taken into account in EuroSea

The scope and implementation of EuroSea is gender neutral, we are looking at ways to improve the ocean observing and forecasting system for increased delivery and impact. EuroSea innovation is focused on societal benefits from the ocean observing system, such as forecast of extreme marine events, and the delivery of information and services. For EuroSea research and innovation activities, the focus is on natural science questions.

1.4 Ambition

1.4.1 Advances beyond the state-of-the-art for marine observations and forecasting

Decades of European investment have resulted in world-leading capability and infrastructure needed to observe, monitor and model the marine environment. Most recently, the Horizon 2020 AtlantOS project has made significant progress integrating Atlantic observing networks, satellite observations, and national and international arrangements for the management of marine data, whilst expanding the use of autonomous observing platforms. It is vital to now build upon the **improved ocean observing networks** and **investment in ocean modelling, assimilation and forecasting** in order to deliver actionable information for policy, planning and society. Through enhanced pull-through of marine data to the demonstrator activities, EuroSea can lead to a step-change in the way that we derive additional value from marine data in support of coastal management and evidenced economic impact. The demonstrator activities are vital in showing how the project findings can be integrated and brought to the market or end users. EuroSea will combine optimized observing systems with ocean analyses and forecasts at global, regional and local scales for environmental protection and the management of emergencies. In particular, the demonstrator activities (**WP5,6,7**) aim to revolutionize the use of marine data for downstream services and products This explicit connection to previous investment allows EuroSea to achieve something beyond its budget and also links strongly to existing EU activity. EuroSea will deliver global coordination and provide the impetus to develop new sensor and platform technologies for ocean observing, new observing strategies (including the use of autonomous vehicles), improve best practices guides, and frame new policies to address this scourge of ocean health. EuroSea activities will directly encourage game-changing technologies in autonomous sampling systems, forcing up the TRL of sensor systems (new variables, more accurate and precise, less drift, lower power consumption, etc.) on gliders and autonomous surface vehicles, by network workshops and articulation of observing needs. The increased use of data assimilation will improve the forecast accuracy of all model products and opens up possibilities of intelligent feedbacks between ocean modelling systems and observational networks (e.g. artificial intelligence guiding the autonomous observations based on assimilated model fields). EuroSea will deliver a new paradigm of operational services and management products to ports and coastal cities. EuroSea will lead to innovation in connectivity, and delivery of relevant information, between operational oceanography and the environmental health monitoring activities with a pilot study in the Baltic Sea and for small-pelagic species in European waters. A novel approach for auditing the role of the ocean, and its limitations, in carbon cycling have direct economic relevance to Blue Bonds and carbon trading, providing vital information to Europe (and all governments) needed to conduct the COP process. EuroSea will enhance collaborative, inclusive, and strategic stakeholder dialogue that moves beyond stakeholder consultation towards co-design of the observing system based on user needs.

1.4.2 Innovation potential

All Work Packages within EuroSea have the specific objective of accelerating the Technology Readiness Level (TRL) of instruments, sensors or platforms, and to integrating these observations with ocean models for societal benefit, or delivering cost-effective actionable information leading to improved ocean governance and optimized marine monitoring strategies.

WP1 will accelerate the inclusion of biological/ecological EOVs in marine observing networks providing policy makers and managers access to **new metrics** to manage performance against international conventions and assessments. It also delivers coordination to ensure reliable baseline information underpinning potential economic

growth in the fields of marine bio-pharmaceuticals and other marine resources. EuroSea aims for **innovation in the ocean observing governance system** and the framing within the legal framework, and will establish the first global network of observations to tackle the growing problem of marine plastic litter. **WP2** will **evaluate and introduce novel components** to marine observing systems, for instance increased coverage of the Argo array, its extension to the deep ocean, and the potential for tropical moorings to improve the accuracy of global CMEMS products such as carbon and heat fluxes. Data assimilation techniques will be improved by combining satellite derived information with biogeochemical in-situ data and CMEMS models; this will lead to innovation for science (e.g. better estimates of ocean acidification) and management (e.g. using model products to frame policy decisions). The outputs of T2.3 will lead to optimized analysis of current satellite missions for ocean variables, and will inform the design of future space borne sensors. **WP3** will deliver **improved integration between observing networks and data delivery**. For instance, innovative demonstration activities will optimize the use of gliders for biogeochemical measurements and outline potential for future glider development and fleet piloting activities. EuroSea will stimulate developments of sensors for deep ocean observatories that are crucial to our improved understanding of oceanic climate below 2000m, where the need for accuracy and low temporal drift is particularly large, and where the high pressure is a technical challenge. EuroSea will **accelerate the adoption of molecular methods** such as genomic, transcriptomic, and related "omics", approaches (i.e. "augmented observatories") to the assessment of the state and change of marine ecosystems with extensive opportunity for the development of further research and innovation. **WP4** will develop innovative forecasting systems including the use of **ensemble forecasts** (a very useful method that is now standard in meteorology but not used in oceanography) to provide **Extreme Forecast Indices (EFI)**, and new synthesized data products regarding carbon in the marine system, in particular a new **synthesized data product** on ship-based time-series, similar to GLODAP and SOCAT. The assimilation of biogeochemical variables marks a step-change in whole system modelling and provides opportunities for downstream products and services relating to coastal management and sustainability policies with the ability to, for instance, predict extreme marine events such as low oxygen or pH that might have negative impact on ocean ecosystem and health. **Improved climate quality datasets** will drive forward the uptake of seasonal forecasting which has numerous economic opportunities. **WP5** will prototype a visualization package for sea level mitigation and adaptation that will provide a new, user-led philosophy towards **sea level services and products** with application to coastal manages and policy makers. The inclusion of private sector partners will ensure that innovative products and services result directly from the work, such as water quality monitoring and prediction, improved navigation safety in the environment of cities and ports. Whilst the scope of activities has a regional focus in the Mediterranean (with a capacity building element in African countries), the resultant products and services have the potential for global uptake and could stimulate the growth of new operational services. **WP6** will explore the delivery of **a new level of forecasting for extreme marine** events to support sustainable industries, food security needs and healthy marine ecosystems, essential for a sustainable Blue Economy. The prediction of, and resilience to, extreme marine events has consequences for the insurance and reinsurance of Blue Economy sectors. Novel instrument solutions for monitoring of ocean health including inexpensive biogeochemical sensor packages will be developed. **WP7** will generate new, user-relevant products for ocean climate monitoring, and deliver seasonal forecasting in support of improved ecosystem management, risk management and blue growth. **Improved marine indicators** will reduce the uncertainty on seasonal forecasting leading directly to economic benefits and follow-on opportunities in services for industries depending on ocean health and long-term forecasts of weather and climate. **WP8** will address the sustainability of the project's results and deliver an input into the ocean observation strategies within the G7, Belmont Forum and UN Ocean Decade, representing major innovation potentials.

2. IMPACT

2.1. Expected Impacts

2.1.1 Expected Impacts set out by the work program under the relevant topic

With reference to the expected impacts listed in the BG-7 call text, the following is an overview of the specific EuroSea contribution:

Expected Impacts in the short term (2-3 year time scale post-project)

1. **Support the implementation of the Future of the Oceans Initiative of the G7 Science Ministers (the Tsukuba Communiqué).**

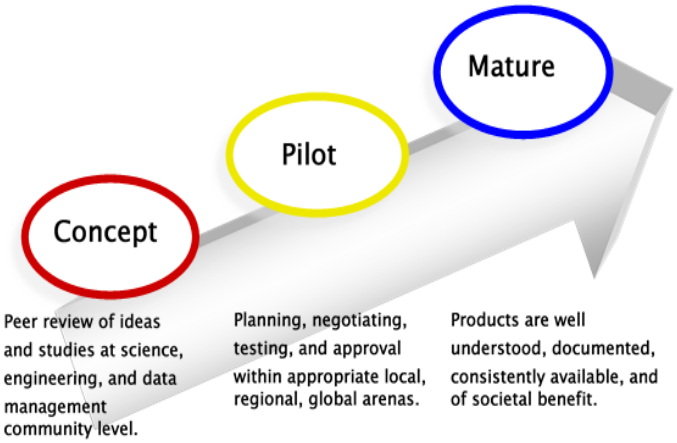
In response to action 1 in the Tsukuba Communiqué, WP3 will oversee key aspects of integration and improvement **of observing networks. EuroSea will deliver more fit-for-purpose observing networks. New observing elements will** be deployed in the demonstrator activities including BGC and DEEP (> 2000m water depth) Argo floats in **WP7**, novel multi-parametric monitoring stations and tide gauges in **WP5**, and novel monitoring stations for ocean health

in **WP6.** EuroSea **WP3** is contributing to challenge 3 of the Tsukuba communiqué on open science and data by providing a tide gauge data flow strategy (D3.3), a EuroSea data handbook (D3.13), and data integration guidelines (D3.17) where EuroSea will provide more efficient and effective ocean data delivery and integration to EMODnet, CMEMS and SeaDataCloud (all major aggregators of European marine data). The demonstrator projects **WP5,6,7**, will facilitate data delivery from the observing networks in a timely way to open and interoperable data systems, where they are integrated in assimilation and forecast systems. EuroSea is contributing to challenge 4 of the Tsukuba Communiqué on regional observing capacity building through: 1) activities in sea level reconstruction (data set covering 67 years) (D5.2); 2) a sea level trend toolbox (D5.8), 3) operational monitoring systems at 3 locations (D5.9); 4) guidance on extreme marine events reporting (D6.3); 5) recommendations on an integrated Baltic system that links directly to policy makers (D6.6); and 6) combining satellites and in-situ strategies (D7.6). Regional observing systems are being implemented around different societal challenges, leading to more fit-for-purpose regional and local ocean observing systems for ocean health, operational services and climate. EuroSea will provide an enhancement of global coordination mechanisms and infrastructure (**WP1**), and build capacity to better use global ocean information (**WP4**). The demonstrator activities will lead to improved port operations in selected African ports (e.g. Alexandria) as well as European ports. EuroSea is also contributing to challenge 5 of the Tsukuba communiqué on increasing political cooperation through coordination support in **WP1, c**onducting foresight on policy drivers for ocean observing (D1.1), and tracking the implementation of the European ocean observing System (EOOS) (D1.8), and by facilitating defining a new governance structure considering the wider legal framework (D1.7).

Indicator	**Target (quantity)**
Number of indicators produced for ocean assessments	Year 1: target indicators available; Year 3; 11 indicators (ocean circulation, surface/subsurface warming, marine heat waves, sea level rise, heat uptake, ENSO, European climate, tropical and subtropical storms and Med heat waves available to users

2. Achieve at least TRL 6 for ocean observations' systems and tools.

EuroSea will enhance the current technology readiness of both observing and forecasting technologies. **WP3** will significantly improve the readiness levels of all observing networks both in terms of technology and the overall framework with three important observing elements a) requirement processes, b) coordination of observation elements and c) data management and information products. Following GOOS, the FOO proposes an observing network approach using Framework Process Readiness Level (FPRL) with three general readiness levels (concept, pilot, mature) subdivided to nine categories linked to the TRL scale (Figure 5).



In the table below the two readiness levels (TRL and FPRL) currently and post-EuroSea are given for each network together with the subsequent deliverables. Better coordination and governance, improvements in sustainability, development of best practices, development and compliance of data policy with FAIR principles are general targets that together with issues specific to each network are expected to increase readiness levels.

Figure 5: *GOOS vision of FPRL*

Network	**Current TRL (FPRL)**	**Future TRL (FPRL)**	**Deliverable**	**Explanation**
Argo	5(5)	7(8)	D3.16	Argo has the highest TRL of the networks and efforts in EuroSea will concentrate on the new DEEP & BGC extensions and their incorporation into the existing network.

Gliders	6(5)	7(7)	D3.9, D3.10	Gliders utilize a mature technology of high TRL. Significant improvements in network coordination, in best practices and data issues are expected.
RVs	6(4)	7(7)	Works hops	EuroSea will provide network coordination and integration at European and International level and improvements in data flow and best practices.
Eulerian obs.	6(5)	7(7)	D3.11, D3.12	Efficient coordination and networking at EU and global level in addition to harmonization of metadata standards, Best Practices, and data quality.
Sea Level	7(6)	8(8)	D3.3, D3.17, D3.18	Standard operation procedures will be improved as well as improvement of the metadata inventory with an analysis of gaps/duplicity in data portal. Network coordination and integration to global efforts.
HF-Radar	6(5)	7(7)	D3.4, D3.14	EuroSea will lead to better coordination and governance structure as well as better data flow and best practices; improvements in tools and products.
ASVs	4(3)	6(5)	D3.5,	Autonomous Surface Vehicles (ASVs) are likely to provide high-resolution data sets for environmental monitoring not currently achieved by existing observing systems. EuroSea will support the development of a network of ASV operators and all associated actions, such as data portal, best practices.
Augmented Observatories	3(2)	5(4)	D3.19	EuroSea will improve the technological and operational (SOP's) improvements as well as the networking and integration into existing operational observing systems.

Forecasting systems will be used in combination with TRL gains in observing systems to generate products with a higher TRL than before. **WP6** will use standardized methodology to identify sea surface Marine Heat Waves and adapt it to identify subsurface marine heatwaves, deoxygenation and low pH events. The TRL of the extreme marine event system will move from pilot to mature status in EuroSea. Existing biological marine data from different marine communities (marine environment and aquaculture) for both SW Ireland and the Western Mediterranean (Alboran Sea) will be merged with forecasting products for use by aquaculture and environmental managers at TRL7. **WP7** will upgrade the Tropical Atlantic Observing System (TAOS) with additional autonomous carbon observations and emerging networks (BGC-Argo) with the goal of reaching TRL7 for delivery of ocean products in the tropical Atlantic. Subsurface chl-a indicators will be provided to the aquaculture and fisheries communities to guide decisions. Climate assessments will be enhanced by higher TRL on delivering information on carbon fluxes.

Indicator	**Target (quantity)**
Number of technologies in project advancing by 1 step on TRL scale over project lifetime	8 technologies (detailed above) by project end
Number of technologies in project advancing by >= 2 steps on TRL scale	3 technologies by project end
Number of new tools developed	1 new tool per year (4 over project lifetime)

3. Contribute to regularly measure 50% of biological and biogeochemical EOVs, including in the sea below 2000 m, and predict negative impacts of ocean acidification and other selected stressors to take timely prevention, notably to protect aquaculture resources by 2020.

EuroSea will directly contribute to observations of 17 (full list provided in section 2.2.3) out of 30 EOVs identified by GOOS (the remaining 13 EOVs are at a very low TRL, primarily in the biology and ecosystems domain area, where TRL 7 would not be achievable over the project lifetime). Only a few observing networks take regular observations of the ocean below 2000m; EuroSea will improve the GO-SHIP repeat hydrography program that regularly monitors the full ocean depth for a range of EOVs (**WP3**) and make policy information available on regional

ocean carbon uptake (D7.5). EuroSea will implement novel observations below 2000m in deep convection areas (Labrador Sea and West Mediterranean) by deploying Deep Argo floats (T and S measurements) with the goal of increasing the TRL of climate related information products on heat content and CO_2 uptake and storage by these regions. This includes a skill assessment of user-relevant ocean indicators (D7.4) to guide European policy users. As ocean acidification is the effect of anthropogenic carbon uptake and pH is one measurable variable of the inorganic carbon system, regional carbon variability will be assessed in **WP7 (**D7.3) to enhance existing observation programs and assets in order to develop a detailed view of air-sea uptake and storage of CO_2 for a major ocean sink regions. The carbon related observing and dissemination pathways will be elaborated through demonstration missions (D7.1**)** in the Labrador Sea, West Mediterranean Sea and the tropical Atlantic to produce ocean acidification information and indicators for those areas. EuroSea will reinforce BGC dataset interoperability, data synthesis and production (e.g. SOCAT and GLODAP), and develop tools to provide regular estimations of key carbon metrics e.g. primary production and carbon export into the ocean mesopelagic zone (100-1000m). EuroSea will develop 3D and 4D products of key biogeochemical quantities to prepare the future use of remote sensing data as a predictor of on-going change in the ocean interior. **WP7s** skill assessment of ocean indicators (D7.4) will benefit from, and improve on, existing data systems towards the development of indicators related to changes in ocean biogeochemistry. Particular emphasis will be put on the tropical Atlantic Ocean regarding CO_2 fluxes at the air-sea interface, downward export fluxes of organic carbon photosynthesized in the upper ocean, and on ocean acidification. These carbon-based indicators are identified as a key parameter under the UN SDG framework (SDG 14), under the EC MSFD framework and for UNFCCC. Demonstrating improved quality of carbon measurements will benefit the implementation of the SDG 14.3.1 indicator for ocean acidification. Hence, much of the activity in WP7 related to strategies around carbon observing will directly assist policy makers in formulating new policies in Europe. **WP6** will implement new data collection solutions and applications for marine sensors to measure and forecast "Extreme Marine Events", such as acidification events, oxygen depletion and heat events at key sites in the NE Atlantic and W Mediterranean. Regular bulletins, hazard maps and forecasts (D6.2 and 6.3) will be provided directly to aquaculture and fisheries operators in these regions. EuroSea will work with end users from industry, e.g. aquaculture (Mowi Ireland) and fisheries (ICES), to determine requirements and maintenance capabilities. In addition, EuroSea will design and implement solutions supporting system deployment and training of users, scientists and local site crew as well as facilitating deployment at key sites. A feedback process is designed for verification of fitness-for-purpose that will provide a satisfaction rating.

Indicator	**Target (quantity)**
Number of EOVs measured by the project	17 by project end
Number of Biological and BGC EOVs measured	Year 1; 5 EOVs, Year 2; 10 EOVs
Number of products delivered to port users	Year 2; 5 products; sea level planning tool, sea level reconstruction, ocean current forecast, wave forecast, sea level trend toolbox. 3 sites operationally equipped
Number of products delivered to aquaculture users	Year 3; Quarterly reports available

4. Lay the foundations for and contribute to the sustainable management and protection of marine and coastal ecosystems to avoid significant adverse impacts (UN SDG 14).

Extreme marine event hazard maps and forecasts (**WP6** (D6.2, 6.3) will be produced based on improvements and recommendations made in the observing system in **WP3,4,7** (D3.7, 4.10, 4.11, 7.4, 7.6). The characteristics of oxygen, heat and pH related "Extreme Marine Events" including ocean circulation, surface/subsurface warming, marine heat waves, sea level rise, and heat uptake will form the basis for products for different end-user groups at varying temporal and spatial scales by integrating in situ, satellite and ocean numerical model data. Such products are important to end-users (e.g. industry suffered losses, environmental monitoring reveals wildlife mortalities, fisheries distribution changes) and will be assessed working with environmental managers to integrate "Extreme Marine Events" data products with existing monitoring programs. The EuroSea framework will be shared with the wider community to facilitate know-how in other regions where such products and forecasts are needed. In **WP5** (D5.1, 5.2, 5.5) EuroSea will develop sea level planning and reconstruction and ocean current, wave and water quality products and services for operational use by coastal cities and adjacent ports in order to minimize risks and improve environmental management e.g. water quality inside the port, beach management and oil spills.

Indicator	**Target (quantity)**
Number of extreme marine events assessments produced	4 per year of project

Expected Impacts in the medium term (3-5 year timescale)

1. Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health (UN SDG 14).

EuroSea will transfer knowledge to different target groups from scientists to stakeholders in Europe and beyond. One important component implemented by **WP1,3,6,8** is the development and articulation of ocean observing Best Practices (BPs) freely available on open access repositories (D1.3, 3.11, 6.3, 8.10). BP documentation is an essential component of the knowledge transfer process that will increase the TRL of the entire system. EuroSea will engage with user-groups and stakeholders to implement knowledge transfer in the demonstrator projects. Within **WP6,** an international ocean observing cooperation will be initiated through co-funding a GlobalHAB stakeholder-science engagement meeting focused on Atlantic Sargassum biohazard issues. In **WP5** (D5.1), EuroSea will prototype a new of low-cost maintenance-free tide gauge system, powered by renewable energy that will be used at European and African sites; with appropriate training activities for the sensor and downstream data and information product development. **WP8** is dedicated to knowledge transfer, and will disseminate the work of EuroSea to both implementers and users through the communication plan (D8.1) and dissemination and exploitation activities (D8.2).

Indicator	**Target (quantity)**
Number of Best Practices produced by the project	One per year
Number of training workshops	12 over project lifetime

2. Improve forecasting of climate change, weather and ocean conditions to protect human activities in support of UN SDG 14 and other relevant goals, and of the objectives of related Conventions (for example, on biodiversity).

EuroSea addresses innovation of forecasting system as a common theme in the whole project. **WP4** will assess the impact that particular ocean observations have on the quality of ocean forecasts (D4.8, 4.9, 4.10) and will improve and implement innovative forecasting systems, using observations to feed the forecast systems, at different space and time scales. Ensemble forecasting at regional level will be implemented specifically to extract Extreme Forecast Indices (EFI). All new products, observational and model data, will be integrated in the Copernicus Marine Environment Monitoring Service and the Copernicus Climate Change Service, thus reaching TRL7 and 8. In particular the use of observations from a wide variety of observing technologies (multi-platform approach) will be assessed in **WP2** (D2.1 - 2.3) to improve the ocean forecast system. In the demonstration projects (**WP5,6,7**) innovative forecast and reanalysis products (D5.3, 5.4, 6.2, 7.4) are provided to assess the improvements in ocean forecasts (TRL 7 is anticipated) and the benefits to users.

Indicator	**Target (quantity)**
New EuroSea data sets assimilated into operational and climate forecasts and reanalyzes	Year 2; Glider data, Year 4; Biogeochemical and Autonomous Surface Vehicle data
Assessment of Biological networks to support MSFD	Year 2; report available to guide implementation
Protocol developed for marine plastics monitoring in European waters	Year 2; Protocol agreed and available

3. Shorten the time span between research and innovation and foster economic value in the blue economy.

EuroSea will shorten the time-span between research and innovation by delivering innovative ocean information and forecast services and products to users. For instance, an advice report will be provided in **WP6** (D6.4) to connect ocean observing and fisheries (ICES) communities in order to develop products for fishery management. The oceanographic forcing on small pelagic fisheries is not routinely incorporated in the advice to the fishery; the concept will be taken to an operational level by EuroSea providing a framework for fast implementation of innovative scientific knowledge to improve end-user relevant services and products. This will create new market and management opportunities for the private sector through co-creation of new ocean products, such as extreme event forecasts, for aquaculture and fisheries. **WP5**, through newly developed software (D5.5, 5.10) will provide a demonstration of new coastal management products for port and harbor operations, e.g. current and wave forecasts, real time monitoring of water quality as well as the delivery of sea level information for policy and planning. End-users will be able to define improvements in the system. **WP8** (through communication and dissemination plans (D8.1 - 8.7) will coordinate the dissemination and engagement outcomes of EuroSea, including business exploitation, enabling/fostering science-policy and public-private partnership interfaces, and strengthening the European

leadership in ocean observing. The goal is to provide better and more precise services to the end-users supporting the growth of the blue economy.

Indicator	Target (quantity)
Number of demos of new services and products	Year 2; 4 demos, Year 3; 3 demos, Year 4; 1 demo

4. Improve the professional skills and competences of those working and being trained to work within the blue economy and in the context of open data sharing.

EuroSea will be improving the skills of both the producers and users of ocean observing and forecast products and services. This will be done by dissemination activities in each WP, and targeted through lessons learned throughout the project **WP8** (D8.3, 8.5, 8.7) to engage professionals in the ocean observing value chain. The transfer of useable downstream services and products to users remains challenging; actors in industry and society do not use existing products suggesting a new approach is needed, e.g. exploring sea level impacts. Within **WP5** (D5.1), we will leverage recent technological developments in data driven modelling and visualization to render large-scale data sets into formats that can be simply and intuitively digested and test them with selected stakeholders. This will enable better coastal resilience decisions in the management of future sea level rise. We will demonstrate the pull-through of data in a number of policy/industry-led applications of these new products. One of these case studies will be in an African country (Egypt) in order to meet the ambitions of the G7 "Future of the Seas and Oceans Initiative" (recommends cooperation with Third Country partners). These case studies will involve capacity building and training activities that enhance the skills and competencies of workers across multiple sectors concerned with sea level change. Intra - network activities (**WP3**; D3.7) include training and improvement of professional skills. In particular, the Autonomous Surface Vehicles emerging network will provide training (D3.5) for engineers and technicians operating the national systems where feasible. Aquaculture operators will be trained in the use of a new sensor system (**WP6**) and in the use of such data combined with model forecasts and satellite imagery to provide information to support to decisions at fish farm level. WP6 will also train fishery scientists and policy makers in the use of Copernicus Marine Service data in support of their science and policy objectives.

Indicator	Target (quantity)
Number of training courses and workshops ran in project	4 per year

5. Contribute to policy making in research, innovation and technology.

EuroSea will support coordination of ocean observing at global, regional and national level for by, for instance, directly support the development of EOOS and the GOOS 2030 Strategy, linking to governmental priorities, specifically those from the G7 WG "Future of Seas and Oceans". The activities in **WP1** will link policy makers, operators of the observing system, and end users. D1.6 will specifically assess the readiness of the existing Biology and Ecosystem observing networks to meet the needs of the EU Marine Strategy Framework Directive (MSFD). Building on previous and ongoing work in Europe and worldwide, **WP1** (D1.1) will assess the current capability for conducting foresight related to ocean observation as part of a regular, iterative cycle of a coordinated and societally-relevant ocean observing system. **WP8** (D8.5, 8.7) will enable/foster dialogue towards co-design, sustained operation and legacy by designing public-private partnership and science-policy interfaces e.g. workshops. EuroSea (**WP7**; D7.3, D7.4) will produce ocean climate indicators for monitoring and forecasting in the Atlantic Ocean and the Mediterranean Sea. These will provide an end-to-end connection from climate and seasonal forecast products for wider use by a wide variety of stakeholders including novel decision-making tools addressed to policy makers (see dissemination plan in section 2.2.2) and products for aquaculture and fisheries communities. A sea level advice demonstrator (SLADE) based on in-situ and satellite measurements will be conducted for the Mediterranean Sea to inform policy approaches to mitigating sea level rise. Marine extreme event warnings on oxygen levels, heat waves and pH will inform aquaculture and fisheries operators of impending events that affect their day-to-day operations and enable long-term analysis of such events to inform national and EU policy in the future.

Indicator	Target (quantity)
Number of project deliverables produced for dissemination in policy arena	Year 1; 2, Year 2; 6, Year 3; 8, Year 4; 14.

6. Increase data sharing and increase integration of data.

Open and free data (following the FAIR principles), integrated into user-friendly products is a cornerstone of the EuroSea principles. EuroSea is particularly focused on the integration aspects of data from different networks related to the challenges related to multi-platform approaches. Recommendations on harmonizing observing networks will be provided in **WP3** (D3.7) examining integration aspects of observing networks, grouped around either specific

platforms or thematic observing challenges (e.g. metagenomics). In particular, WP3 will ensure data delivery for all networks is according to defined standards encompassing communication pathways between platform operators, observing networks and data centers, which will directly increase data integration, *and sharing.* For instance, **WP3** will develop a BGC Argo data validation tool, i.e. a methodology to increase carbon data quality of the emerging BGC-Argo network that will be demonstrated in **WP7** (D7.6) and reducing uncertainties in CO_2 flux estimates and ocean acidification indicators (**WP7;** D.7.2**)**. The integration of multi-platform observations together with numerical models is one of the key challenges today in ocean observing and forecast. EuroSea will develop a *Strategic European Vision of Ocean Integration* (**WP3**; D3.8). In addition, a coordination body or group will be established to oversee the integration across observing networks and to advance common strategies and response capacities to build and establish the European Ocean Observing System (EOOS). One main objective for EuroSea (**WP3**; D3.7) is to ensure that data sets (physics, biogeochemistry) will be ingested in the Copernicus Marine Service and EMODnet portfolios assuring availability of the data for modelling and data assimilation systems used for downstream forecasting systems, EOV assessment and blue growth users.

Indicator	**Target (quantity)**
Number of new datasets contributed to Copernicus and EMODnet	5 per year
Number of new data originators linked to the project	5 per year

2.1.2 Improving Innovation Capacity

Through cooperation between commercial (including SMEs) and academic partners, EuroSea will develop a number of innovations through collaborative efforts through the ocean observing and forecasting systems. In **WP5**, Spanish SME Nologin will develop bespoke software (OSPAC) for ports that provides sea conditions, rip current analysis, flushing times, floating debris and flood and erosion risks. This software will be demonstrated to the ports of Barcelona, Taranto and Alexandria within the EuroSea project. Nologin plans to exploit the software in other ports and cities after the project phase. ARUP, an international engineering company will design a new approach to modelling the interactions between sea level hazards, economic activity and risk. Recent technological developments in data driven modelling and visualization will lead to prototype scenario planning and visualization tools, as well as unlocking the full value of sea level data to demonstrate the pull-through of data in a number of policy/industry-led applications. Xylem, an established marine instrumentation company (in **WP6**) will develop a new application for marine sensors to measure and forecast "*Extreme Marine Events*" onsite with practical training provided to the aquaculture industry in particular to set-up, operate, maintain and interpret the data products produced. This will be pursued as a new business line for the company following development and demonstration in EuroSea. An analysis of the innovation potential of each work package is listed in Section 1.4.2.

EuroSea will explore and further the innovative potential in emerging observational areas, such as those of genomics and (meta)genomics (**WP3**) and new model capacity for better forecast systems (**WP4**), although the main focus of EuroSea is on the innovation potential on the integration networks and models that have a TRL of at least 4.

EuroSea is in particular focusing on innovation of the full value chain of ocean observing - from the requirement setting through observing, data delivery and information and forecast delivery - for three demonstration projects focused around operational services, ocean health and climate. The demonstration projects will follow innovative ways for co-development of services with our partners and customers to ensure that the innovations being developed in EuroSea will be ready for the marketplace, ensuring increased competitiveness of European companies, supporting the growth of the blue economy in Europe. Improving the European in-situ ocean observing system and making the data readily available or integrated with satellite observations and models through the Copernicus Marine Service will allow the development of innovative ocean services by the private sector for use. This includes maritime transport (ship routing), marine renewable energy (weather windows for safe wind farm servicing), aquaculture (early warning of oxygen minima, pH conditions and marine heatwaves affecting the health of finfish and shellfish), fishery (sea state warnings and environmental conditions influencing fish distribution), tourism (beach forecasts, wave conditions). In Section 1.3.2 we have provided an indication of expected TRL levels for the technologies and processes to be developed within the project and the general positioning of the project.

2.1.3 Other Substantial Impacts

In addition to the expected impacts set out by the work programmer, EuroSea will:

a) Create new market opportunities, strengthen competitiveness and growth of companies. Commercially exploitable results (see section 2.2.3) from EuroSea will enhance companies involved in blue growth i.e. port authorities, aquaculture producers and fishery managers. This will be done by providing services based on ocean observations and forecasts leading to efficiencies and early warning of potentially disruptive events e.g. oil spills and pollution in ports and beaches, algal blooms, low oxygen and pH events that threaten farmed finfish and shellfish.

WP7 will deliver assessments the role of the oceans and seas in the Earth's climate through ocean climate indicators (D7.4) and their value for key end-users. EuroSea will generate observable and user-relevant marine indicators with the aim to provide end-to-end connection from climate and seasonal forecast products to a wide variety of stakeholders using innovative decision-making tool for decision makers and other stakeholder such as in aquaculture and fisheries. D6.1 is developing forecast products for extreme marine events (oxygen, heat, and pH) that will be of great value for aquaculture companies and for the fishing industry, but also for the general management of the marine biological resource by the authorities.

b) Address issues related to climate change and to the environment. WP4 will deliver novel decision-making and forecast tools for policy and planning. **WP5** will deliver coastal management analyses and forecasts products on sea level and oceanographic services for ports and cities such as water quality, navigation safety, beach safety (e.g. rip current forecasts and sea state monitoring and forecasting), and improved efficiency of port operations.

c) Offer important benefits for society. As forecast of extreme marine events and the delivery of information and services will be significantly strengthened by EuroSea products, the societal benefits from the ocean observing system will be large.

2.1.4 Barriers/obstacles to achieve the expected impacts

Some of the potential barriers to achieve the impacts expected of the project include:

- Inertia at national levels to have a single voice for ocean observing (many competing national actors);
- Funding challenges regarding the overall sustainability of observing systems at national level;
- The lack of a national framework for marine issues, e.g. a dedicated ministry, is often a barrier to formulating strategies and funding for ocean observation. This leads to poor uptake of scientific results and transfer of technologies and non-sustainable ocean observing systems.

There is some uncertainty around the precise mechanisms available to input to ocean assessments, European directives e.g. MSFD, MSP, DCF, the IPCC process and the UN SDG initiatives where there is often low awareness of established channels of communication. Establishing a strong link to end users of ocean information can often be a challenge. When dealing with specific sectors the loyalty to an existing product or service or over-specialization of staff in those sectors can be a barrier to uptake of newly developed products and services. Finally, protectiveness regarding data release can be manifested in academia, industry and the public sector for various reasons.

2.2 Measures to maximize impact

EuroSea has deliverables designed to respond to different project objectives and spanning the breadth of ocean observing stakeholders and users of the project's results. **WP8** will oversee the dissemination and exploitation of the project's results through targeted outreach strategies:

- **Policy users** will require short and concise recommendations and visual documentation which sets out the EuroSea findings in the broader international and European policy landscape;
- **Business users** will need robust exploitation plans and risks and benefits assessments for EuroSea results, as well as methodologies and networking opportunities;
- **Science managers** will need the results of the mapping and viability studies of the current system and the solutions towards making it fit-for-purpose;
- **Scientific users** will receive know-how in data acquisition and management, technological advances and foresight, and will be able to use the data and results;
- **Public users** will receive awareness-raising materials to improve their ocean literacy and increase citizen's responsibility for sustainable use of the ocean resources.

2.2A Dissemination and exploitation of results

2.2.1. EuroSea Dissemination Plan.

The dissemination objectives are targeted at EuroSea stakeholders who are expecting to see the results (e.g. policymakers) and who will be directly interested by them (e.g. national decision-makers, funders, scientific community). EuroSea outputs are the results of the project's deliverables that may have been adapted to efficiently reach the targets (e.g. a report can be turned into a science-oriented webinar and a policy-oriented infographic). A detailed communication and dissemination plan (D8.1) will be co-designed with partners, encompassing:

Observing, monitoring and their management: 1) operators of national observing networks in Europe; 2) oceanographic research managers and funders (e.g. Belmont forum, G7 ministers); 3) businesses involved in ocean observing and data collection; 3) oceanographic research community (e.g. national, pan-European, global networks, POGO); 4) joint programming initiatives (e.g. JPI Oceans and JPI Climate); 5) regional sea conventions (e.g. OSPAR, HELCOM, Barcelona and Bucharest conventions, ICES); 6) satellite industries and agencies (e.g. ESA and

EUMETSAT); 7) European and international weather forecasting centers (e.g. ECMWF and WMO); 8) the ocean observing community (e.g. GOOS, EuroGOOS, IOOS, CIOOS and the GOOS expert panels).

- EuroSea output examples: 1) fact-sheets on European ocean policy landscape; 2) maps of ocean observing capacities; 3) ocean biology and ecosystem observing capability map; 3) scientific publications, e.g. on multi-platform system design and observing networks assessments; 4) report cards on building science-policy and public-private interfaces; 5) guidelines documents on open on-line portals.
- Dissemination tools and performance targets: 1) webinars on project results targeted at stakeholders (at least 6); 2) presentations at relevant events (at least 10 per year); 3) exhibition stands at relevant events (at least 2 per year); 4) newsletters (at least 2 per year); 5) scientific publications (at least 4 per year); 6) updates to the Ocean Best Practice portal (at least 2 per year).

Operational and data services, and forecasting: 1) port operators and local coastal communities; 2) European and international ocean data aggregation initiatives (e.g. EMODnet, Copernicus, SeaDataNet, PANGAEA); 3) international initiatives in Earth and Ocean observations (e.g. GEO and its Blue Planet initiative); 4) research infrastructure initiatives (e.g. ESFRI); 5) environmental research infrastructure data management initiatives (e.g. ENVRI FAIR).

- EuroSea output examples: 1) data flow strategy reports; 2) handbooks on data management, integration and standards; 3) reports on satellite validation and integration of in situ and satellite multi-platform data; 4) new forecasting products on the Copernicus Marine Service (CMEMS); 5) new public and private data available on CMEMS and EMODnet; 6) open automated data quality control software; 7) automated tide gauge quality control software.
- Dissemination tools and performance targets: 1) mailings to relevant stakeholders with information on new reports and open portal updates (approx. 6 per year); 2) presentations at relevant meetings (at least 6 per year); 3) data-oriented open webinars (at least 4); 4) workshops with data integrators (at least 3); 4) updates to the open Ocean Best Practice repository (at least 2 per year); 5) meetings with port operators and local coastal communities (at least 3).

Science for society: 1) European Environment Agency and Joint Research Centre; 2) international assessments (e.g. World Ocean Assessment and Global Ocean State Report, UNFCCC and the IPCC); 3) the UN Ocean Decade Executive Planning Group; 4) OECD Ocean Economy activities.

- EuroSea output examples: 1) sea level planning and scenario visualization tools; 2) report cards on Extreme Marine Events and Biological EOVs; 3) report on the magnitude and drivers of regional carbon variability; 4) report on economic value of ocean observations.
- Dissemination tools and performance targets: 1) direct correspondence to targets announcing the outputs; 2) EuroSea-organized bilateral meetings with EEA, JRC, IOC and OECD (at least 4); 3) participation/presentations/exhibitions at the UN Ocean Decade regional planning workshops and global meetings (at least 2); 4) European Maritime Day exhibition stands (at least 4).

Programming and legislation: 1) European Commission (e.g. Horizon Europe, Marine Knowledge, Directives including INSPIRE, MSFD, MSP, CFP, DCF, and Plastics, Copernicus programme) spanning relevant DGs, (e.g. Research and Innovation, GROW, MARE, CLIMA, Regio, Environment; 2) European Parliament (e.g. intergroups, committees, individual MEPs); 3) Ocean Governance committees (e.g. Biodiversity Beyond National Jurisdiction and Maritime Spatial Planning); 4) UN Office to Disaster and Risk Reduction (Sendai Framework for Disaster Risk Reduction); 5) International science and science-policy milestone events (e.g. OceanObs'19, Our Ocean, UN SDG14 conference); 6) National and Regional; 7) the Belém and Galway agreements.

- EuroSea output examples: 1) brief on ocean observing policies and foresight recommendations; 2) report card on the use of legal frameworks for ocean observing; 3) infographic on the benefits of the regional integration between operational and environmental programs; 4) brief on marine plastic contaminant monitoring; 5) responsible Research and Innovation guidelines for ocean observing system design, exploitation and sustainability; 6) ocean observing system infographics; 7) infographic on economic value of ocean observations; 8) EuroSea Legacy Report.
- Dissemination tools and performance targets: 1) European Parliament events (at least two); 2) presentations at European Commission and the Council of the Regions meetings (at least 4); 3) targeted mailings; 4) exhibition stands and networking at EC, EP and international conferences (at least 12); 5) bilateral meetings with MEPs (at least 2); 6) meetings with national representations in Brussels (at least 4).

WP8 will not only use the EuroSea's own dissemination tools and channels, but also *other relevant channels*, both from the project's partners and outside (e.g. EuroGOOS, EMB, IOC/ UNESCO, GOOS, EurOcean European Centre for Information on Marine Science and Technology, European Commission's Maritime Forum, JPI Oceans).

2.2.2 Business plan and results exploitation

Commercially exploitable results and their users.

The main commercially exploitable results that are expected from the project have been listed below. Three of these results, one from each of the demo WPs have been expanded on in the business plan summaries. The results that will be used for further research purposes are included at the end of this section. The list will be assessed and updated throughout the project.

- **Prototype low maintenance multi-parametric monitoring station** to monitor both land motion and sea level (D5.7). Users: Port and harbor authorities, MSFD implementers in all European countries, Search and rescue operators, Tsunami alert authorities, Developing countries impacted by coastal inundation (worldwide).
- **Prototype sea level planning and scenario visualization tool** to model the potential future impact of sea level rise (D5.1). Users: Port operators and local coastal communities; Marine Spatial Planners; Insurance industry.
- **Oceanographic Services for Ports and Cities (OSPAC) software on port and city real-time alert** to provide forecast of sea conditions (D5.5). Users: Port operators and local coastal communities.
- Solution for marine sensors to measure and forecast oxygen, heat and pH related Extreme Marine Events onsite for aquaculture (D6.8). Users: Aquaculture and fishery companies.
- **Carbon audit to evaluate the economic value of the ocean carbon sink** (D7.3). Users: European Environment Agency, Joint Research Centre, International assessments, including the UN World Ocean Assessment and the IOC-UNESCO Global Ocean State Report, UNFCCC and the Intergovernmental Panel for Climate Change.
- **User-driven calibrated seasonal forecast ocean indicators** (D7.5). Users: European Environment Agency, Joint Research Centre, Aquaculture companies, Fishery companies, Transport.

In order to ensure that the EuroSea development partners are focused on the market exploitation of their results from the early stages of the project an Exploitation Manager will be appointed and an Exploitation Board established for the project duration. The Exploitation Manager will be provided by the Marine Institute and will report to the Board comprising of Technology Transfer experts in several EuroSea partner institutes and representatives of the SMEs and companies within the consortium (ARUP, Xylem and Nologin). A sub-contract will be issued to an IPR consultancy (T8.3) to engage external expertise for the consortium in identifying exploitable results as the project progresses. The expertise will be used to draft an IPR management plan to outline how foreground IP generated from the innovation projects will be dealt with. This will involve specific training sessions to help with recognition of IP for project partners who have potentially exploitable results. A more detailed exploitation strategy will be developed within the first six months of the project (D8.4) to enable the potential commercialization of the results and the broad use of the results for further research purposes, addressing different stakeholders. The key exploitable results from the project will be updated at this point. A detailed market analysis will be conducted by the Exploitation Manager to determine the market value, the size of the market share targeted and the market trends and outlook for each of the demos that show the most potential for commercialization. Various business development tools (SWOT, PEST analysis) will be used to support partners in the exploitation of the demos. In addition, the co-development of the demo products/services with the end users will help to ensure that market and specific customer needs are fulfilled.

Business plan

A detailed business plan will be developed to emphasize the value added of the EuroSea project. This will build on the work done in the exploitation strategy, taking into account the exploitable results of the project and developing a business plan that incorporates the innovative products/services produced, particularly in **WP5,6,7**. The plan will assist partners in taking their products/services to market by outlining suitable pathways and options available to do this. The plan will also explore funding options to enable the continuation of the enhanced observing system post project. The Canvas model[9] below has been prepared for the EuroSea business model. The business canvas model is a visual chart that provides a brief description of the value proposition of EuroSea, the demonstrations products and services, the customers and the financial framework. This model will be modified and enhanced during the project as part of **WP8**.

The initial **business plans** for one of the potential commercially exploitable products and services from each of the demo WPs are summarized in the tables below.

[9] Business Model Generation, Alex Osterwalder and Yves Pigbuer, 2010.

Business Model Canvas

<table>
<tr>
<td rowspan="2">Key Partners
EuroSea consortium, Ocean Observing Networks, Assimilation centers, Government agencies, Aquaculture, Fishery, blue economy companies, Instrument developers.</td>
<td>Key Activities
Coordination and integration of ocean observing and forecasting systems, data management, co-development of demonstrations.</td>
<td rowspan="2">Value Proposition
An integrated and fit-for-purpose ocean observing and forecasting system, provision of ocean products/services around the societal benefit areas of climate, operational services and ocean health.</td>
<td>Customer Relationships
Workshops for co-development, training courses, conferences, operational day-to-day contact.</td>
<td rowspan="2">Customer Segments
Government agencies and regulators, Policy-makers, Aquaculture, Fisheries, Tourism, Port operators, Coastal communities, Climate assessments.</td>
</tr>
<tr>
<td>Key Resources
Ocean observing and forecasting networks and capabilities, Data integrators</td>
<td>Channels
Direct distribution, EuroSea website/communication channels</td>
</tr>
<tr>
<td colspan="3">Cost Structure
Development of products/services, integration/coordination, system design, customer/end-user support, operation of observing networks and assimilation models.</td>
<td colspan="2">Revenue Streams
Income generated from commercialization of products/services, national and regional funding agencies and entities, funding programs and mechanisms, sale of instrumentation packages.</td>
</tr>
</table>

Demonstration name	**Operational Services**	
Type of Product/Service	Operational Services for Ports and Cities (OSPAC) software (D5.5)	
Owner	EPPE and Nologin	
Description of product features	**Background IP**	**Foreground IP**
	Downscaled operational forecast models for wave, sea level, sea surface temperature and circulation based on boundary conditions provided by CMEMS system	An OSPAC software product will be developed using existing forecast models and real-time data. The software will deliver real-time alerts by SMS and email to provide forecasts of sea conditions, rip currents, flushing times, floating debris and flood and erosion risk.
Industry sectors	**Target and potential customers**	
	Port authorities including those at the pilot sites in Barcelona, Taranto and Alexandria. City halls, Companies working at the ports, Marine litter control, Oil spill response.	
Market size	The top 15 ports in Europe experienced an increase in container traffic on the previous year of 4.2% in 2017. The Port of Barcelona was the fastest growing European port in 2017 in terms of traffic and had a turnover of €167 million and profit of €50 million. The Port of Alexandria had a turnover of approximately €80 million in 2016.	
Customer needs	Improved real –time alerts for water quality, navigation safety, safety on the beaches, improved efficiency of port operation, etc. The specific customer and end user needs will be defined through the co-development process.	
Impact for customers	Real –time alerts will lead to improved efficiency of operations at ports, cost reductions and improved navigation safety.	
Exploitation	Commercial exploitation – joint ownership of IP generated during project by EPPE and Nologin	

Demonstration name	**Ocean Health**

Type of Service	Module: "*Extreme Marine Event*" alerts to Aquaculture (D6.8)	
Service Provider	Xylem-Aanderaa	
Description of service features	**Background IP**	**Exploitable results (Foreground IP)**
	Sensors from Xylem: Telemetry solutions: Buoys, moorings and platforms: Standardized methodology to identify Marine Heat Waves	The innovative solution is an increased operational ability connecting *in-situ* sensors (for oxygen, temperature, turbidity, currents, waves, salinity, pH, ORP and algae) via telemetry to land where data is processed in a user-friendly interface to give an environmental alert. The service, with the added value data alert products, increases the marketing potential of the commercial sensors. The service includes practical training to set-up, operate, maintain and interpret the data products.
Industry sectors	Current customers Aquaculture, research, environmental monitoring, ports and harbors, offshore wind, oil and gas.	**Target:** Mowi, Ireland **Potential Targets:** Seafood companies, Government agencies, academic institutes etc.
Market size	The global aquaculture market size was valued at approximately €150 billion and is expected to grow to €190 billion by 2022. Mowi is one of the largest seafood companies in the world with turnover of €3.6 billion globally in 2017. Mowi Ireland had turnover of €77 million and profit of €23 million in 2017.	
Customer needs	Improved real-time and modelled environmental alerts and forecasts of the impacts of oxygen, heat and pH related extreme marine events. The co-development process will define the specific customer needs and determine maintenance capabilities and the level of training required	
Impact for customers	The services will help to optimize aquaculture operations and could potentially reduce financial losses from stock damage caused by Extreme Marine Events.	
Service Roadmap post project	The service described is delivered by Xylem to new customers and a well-defined fixed-price service is established. Build on market experience to include *in-situ* sensors with new capabilities; cost and extent of the service is defined by customer specified needs.	

Demonstration name	**Climate**	
Type of Service	Carbon audit to evaluate the economic value of the ocean carbon sink	
Service provider	GEOMAR and IfW	
Description of product features	**Background IP**	**Foreground IP)**
	Existing economic methodologies on the value of carbon storage, and Existing scientific methodologies calculate of carbon sink	Combination of scientific and economic methodologies to provide more accurate valuations of the ocean carbon sink. Operationalization of the carbon audit as a CMEMS indicator and connection to the Ocean State Report.
Target and potential customers	Government agencies and planners, Carbon offset companies, World Bank.	
Customer needs	Regular and more accurate estimates of the ocean carbon sink and the value of this sink. Updated information on the value of the ocean carbon sink is required for effective marine spatial planning. End user feedback will be used to determine how to operationalize the audit.	
Impact for customers	Improved decision-making on the sustainable management of ocean resources based on more accurate estimates of the value of the ocean carbon sink. Improved global environmental accounting frameworks such as the UN Inclusive Wealth Report.	

Non-commercially exploitable results and their users

EuroSea results will include also non-commercially exploitable results, which will respond to the needs of users spanning the observing network operators, port and coastal managers, and policy users.

Some highlights of non-commercially exploitable results include:

- **Ocean biology and ecosystem observing capability map** (D.1.4). Users: Operators of national observing networks in Europe, Oceanographic research community, Policy users (MSFD, DCF, and Ocean Governance)
- **Marine plastic monitoring plan and EOV common sampling protocol** (D1.6). Users: European Environment Agency, Joint Research Centre, The UN Ocean Decade Executive Planning Group, Operators of national observing networks in Europe, Oceanographic research community, national ministries responsible for the implementation of the future Plastics directive;
- **Automated tide gauge quality control software** (D5.5). Users: Port operators and local coastal communities (e.g. Barcelona, Taranto, Alexandria);
- **Copernicus Marine Service data products for fisheries management** (D6.3). Users: Fisheries companies; governmental fishery agencies
- **Lessons learnt on public-private and science-policy interfaces for knowledge transfer and impact generation** (D8.3 and D8.7). Users: European Commission, European oceanographic community;
- **Recommendations on the implementation of Responsible Research and Innovation in the ocean observing system design** (D8.9). Users: European Commission, European ocean observing funders, Oceanographic community;
- **Knowledge transfer seminars and workshops for the next generation of professionals across the ocean observing value chain** (D8.11). Users: Higher education institutes, maritime industries, national education and research ministries, European Commission.

2.2.3 Management of Data generated/collected during the project

A consortium agreement will be set up for regulating the ownership and access to key knowledge (IPR, data etc.) and scientific foreground, among other things. This will allow us to collectively and individually pursue market opportunities arising from the project's results, where relevant.

For the management of ocean observation data, we have established a distributed responsibility approach across the project. The first step of the data ingestion process is done on a network level with dedicated support from the observing networks for data management activities in **WP3**. There is also a specific task in WP3 on " Interface with In Situ data integrators" (T3.10) that will ensure close collaboration between observing network operators, data managers and targeted user needs. The main objective is to ensure that new or consolidated EuroSea data sets (physics, biogeochemistry) will be ingested in the Copernicus Marine Service, SeaDataNet and/or EMODnet portfolios. Specifically, integration in CMEMS and EMODnet will be achieved by harmonizing workflow between the observing networks and the data Integrators through interoperable interfaces based on existing, international standards and additionally visualizations will be demonstrated. EuroSea will support creation of EOV specific data products, i.e. network independent, for biogeochemistry (T4.5). EuroSea will create a more detailed Data Management Plan (D3.1) for making data findable, accessible, interoperable and reusable (FAIR).

Types of data generated/collected by the project: The majority of the data in the project will be generated in the demonstrator activities (**WP5,6,7**) and only to a limited extent in WP3 around network improvements. This in particular true for the task (T3.8) on augmented observatories where biological data on will be collected in a pilot study. EuroSea data are coming from different observing platforms using a range of sensors and instruments, all with high TRL. The focus on measurements is on autonomous platforms equipped with fit-for-purpose sensors, but also the processing of ship-based observations will be improved. EuroSea will collect physical, chemical and biological EOVs from the surface to the deep, and from the open to the coastal ocean. EuroSea will observe the following EOVs (17 out of 30): Sea state, ocean surface stress, sea surface height, sea surface temperature, subsurface temperature, surface currents, subsurface currents, surface salinity, subsurface salinity, oxygen, nutrients, inorganic carbon, particulate matter, dissolved organic carbon, phytoplankton biomass and diversity, zooplankton biomass and diversity, microbe biomass and diversity. In addition EuroSea will make observations of metabarcodes / amplicon sequences (targeting the 16S and 18S rRNA genes), metatranscriptomes (mRNA sequences) and metagenomes (DNA sequences) in T3.9 - augmented observatories pilot experiment.

Data management activities will be supported and improved by observing networks as listed below:

- **GO-SHIP / Research Vessels:** Present GO-SHIP data standards (provision of reference quality measurements).

- **SOOP** (Ships of Opportunity): Common data handling and quality assurance (for carbon IOCCP developed standards). EuroSea will support the coordination and improvement of SOOP (incl. FerryBox) observations and streamline observation requirements and data flow.
- **Argo:** EuroSea will consolidate Euro-Argo ERIC Management Board DEEP and BGC strategy and the Best Practices for operations and data management will be developed.
- **Ocean gliders:** EuroSea will develop best practices for glider operations and data management. EuroSea will support development of reference documentation for, in particular, BGC data delayed mode quality control.
- **Eulerian observatories:** EuroSea will harmonize best practices concerning the maintenance and operation of various autonomous sensors measuring an expanded range of EOVs, as well as data quality control and metadata and data management, including data covering aspects of the deep sea floor community. In addition, the EuroSea will improve metadata integration across the network.
- **Sea level gauges:** The multiple applications of sea level gauges lead to very diverse data portals with different requirements. EuroSea will establish a metadata inventory of stations and conduct an analysis of gaps and redundancies in data portals providing tide gauge data, and design of a new strategy for data flow for tide gauge data storage, quality control and distribution. EuroSea will assess and compile an on-line portal of uplift and subsidence land data and produce a road-map and strategy for new tools for automatic quality control and processing for sea level observations
- **HF Radar:** EuroSea will improve the availability of HFR data through implementation of best practices of operations and maintenance following the FAIR principles. EuroSea will also develop tools supporting the advanced delayed mode QC of HFR and added value products, supporting intercomparison of model outputs and HFR products. In addition, an outage online reporting database will be implemented, and a troubleshooting document will be produced to complete the existing best practices. EuroSea will support operators for implementing the standardized NRT data flow through the EU HFR Node, and guide standardized quality assessment and data management.
- **Autonomous Surface vehicles (ASVs):** EuroSea will promote the creation of the first ASV network by establishing the network structure, documentations (standard operating procedures (SOP), protocols), data management, knowledge transfer and risk assessment.
- **Augmented observatories**: EuroSea will collect microscopic data (cell counts), metabarcodes / amplicon sequences (targeting the 16S and 18S rRNA genes), metatranscriptomes (mRNA sequences) and metagenomes (DNA sequences) at selected LTRE sites. EuroSea will support ongoing efforts to bridge macro-organismal occurrence data with the INSDC sequence data using SILVA as a core taxonomy service (and an ELIXIR node). The EuroSea metadata will comply with and propose observatory-focused extensions to the Minimal Information about any (x) Sequence (MIxS) standards from the Genomic Standards Consortium (GSC). EuroSea will ensure that metadata and data follow FAIR principles. EuroSea augmented observatories will be processed for the inclusion into OBIS and other similar initiatives.

2.2.4 Strategy for knowledge management and protection

It is anticipated that the value of the Intellectual Property (IP) produced by EuroSea lies in the ability to produce data products, improved forecasting systems, and targeted products and services. The impact of the project is dependent on an informed and consistent approach to the IP management. A strategy for knowledge management, protection and the exploitation of results will be defined in the Exploitation Plan [D8.2] in the early stage of the project. This will be devised with the focus on the objective of practical development and exploitation, but always taking into account the legitimate interests of the beneficiaries where there may be good reasons for wider dissemination and academic publication of aspects of the work. It is anticipated by the partners that the requirements for access to Background IP and the protection and exploitation of Foreground IP can generally be met by the approach contained in the Commission's Model Grant Agreement and the new DESCA Model Consortium Agreement for Horizon 2020 projects. The plan for the use and dissemination of foreground will detail the intended approach beyond the lifetime of the project, including issues such as whether foreground should be licensed and at what stage. Beneficiary institutions and individuals involved in the project will be expected to act as ambassadors and interpreters for the results of the project in the role most suited to their expertise. The management of the IP generated by the project will be carefully monitored by the Executive Board, via the project coordination unit (PCU), to ensure that it complies with the obligations of the beneficiaries under the grant agreement with regard to IPR, dissemination and use issues. The PCU will ensure that the requirements for data collection and storage, Community access to Foreground IP and possible transfer of Foreground IP are in place. The Consortium Agreement will be formulated to support these obligations, with a particular emphasis on responsibilities for internal management of IP, identification of access to Background IP for the purposes of carrying out the project and the arrangements for the use of the Foreground

generated. The PCU will ensure that the Commission is kept fully informed of all dissemination and use activities, and in particular, will take responsibility for the formulation of the plan for the use and dissemination of foreground.

We are aware of the importance of wider access to scientific publications and data; therefore, EuroSea will ensure that electronic copies of peer-reviewed scientific publications become freely available as soon as possible and in all cases no later than six months after publication. Generally, EuroSea will privilege Open Access Journals for publishing scientific articles. If not possible authors will pay an extra fee for fulfilling the EC Open Access requirement, opting for Golden, or green, OA options. Articles will be made available in the institutional repository of the institutes where the authors work or on the EuroSea website.

Openly accessible research data can typically be accessed, mined, exploited, reproduced and disseminated free of charge for the user. A Data Management Plan (D3.1) will outline how the research data collected or generated will be shared and/or made open, and how they will be curated and preserved during, and after, the EuroSea project.

2.2b Communication activities

The EuroSea communication activities will encompass dissemination, engagement, exploitation and legacy work. The project's communication, managed by **WP8**, will deliver a critical support to the project and its demonstrators, assisting EuroSea in the delivery of viable and targeted outputs, displaying how EuroSea is improving the information provision to a range of users and stakeholders, while also contributing to a lasting legacy. All project partners will be actively involved in co-design of the project results and outputs and engage in their active promotion. EuroSea will set up an effective internal communication system enabling easy and open access to information and a collaborative platform for exchange among partners, so that their valuable expertise is optimally and efficiently employed and transferred through the project.

EuroSea communication messages will expand on the project's vision (see section 1.3.1) and the precise requirements of the stakeholder engagement (see sections 2.1 and 2.2.A). Different stakeholder groups will be approached differently, depending on their readiness to understand and take up the communication messages. Each stakeholder's culture and paradigm will dictate the choice of communication approaches. Detailed communication and dissemination plans (D8.1 and D8.2) will be co-designed with partners.

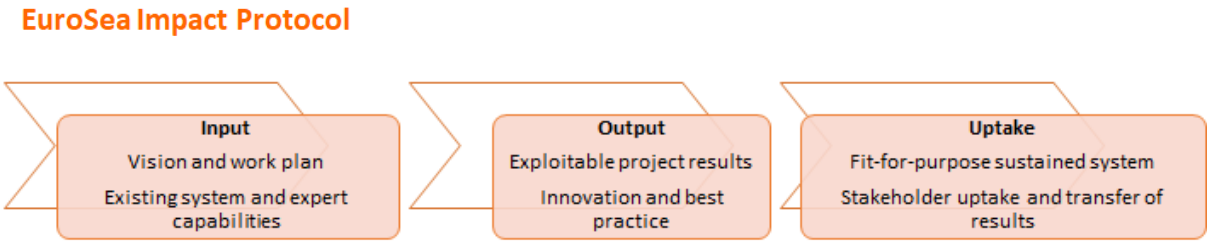
EuroSea dissemination channels and plans are described in part A of this section. In addition, EuroSea will use the following communication tools to engage with the respective audiences:

- **Project website** will include general project information sections, pages for the partners and interested audiences, as well as pages for policymakers and the general public featuring YouTube videos on oceanographic activities, the EuroSea public awareness video, infographics, etc.
- **Twitter account** will help attracting much broader audiences to the project's highlights and bring traffic to the website. Some types of EuroSea targets are particularly active users of twitter, e.g. policy and decision-makers as well as EU projects and initiatives. Twitter will also help reaching out to the general public with awareness raising videos and infographics. EuroSea will aim at reaching at least 1,000 followers by the end of its lifetime.
- **Newsletters** to subscribers and the consortium will be circulated at least twice a year. News flashes will also be circulated to the mailing list on specific updates (e.g. release of a new output or an impactful event) – at least 4 news flashes per year are foreseen. The news mailing list subscribers will include the EuroSea results stakeholders (see part 2.2A), and will raise the project's general visibility through pushing them via Twitter.
- **Stakeholder events, workshops and briefings** for focused engagement with specific users and targets, e.g. the users of the demonstrators' results (**WP5,6,7**) from the public and private sectors, i.e. fisheries and aquaculture, tourism, national environmental agencies and users of CMEMS and EMODnet services. Additional stakeholder activities are described in section 2.2A. The spill-off effect of those activities will include engagement with local stakeholders; events are planned for >4 countries, including Brussels and Copenhagen (housing the headquarters of the European Environment Agency and ICES).
- **Webinars** on EuroSea results for interested public will be organized – at least 4 (WP8) to interface with general public or new interested stakeholders on the EuroSea work.
- **Capacity building activities** will include trainings for scientific and technical users on targeted engagement and communication through science-policy and public-private interfaces. For instance exploitation of EuroSea results and engagement with business, science communication, and external trainings, e.g. European Commission seminar on ocean observing, data products and services. EuroSea will also conduct technical capacity trainings for: 1) the use of the EuroSea's innovative oceanographic products for sea level measurements in ports and cities; 2) technical skills training on costal management tools with African partners; 3) trainings on the use of EuroSea's innovative Extreme Marine Events mapping and forecasting products for industry, government and scientific customers.

- **Conferences and exhibitions** for science and technology users, peers and broader networks and system operators (at least 8) including, OceanBusiness, Oceanology International, European Maritime Days, BlueInvest, MSP Global, Biobased Economy Conference, EGU, Ocean Science, GEO plenary exhibitions.
- **Public and policy engagement and awareness raising activities** will include participation in general public events, e.g. World Ocean Day national and international events as well as national ocean-focused events like the Irish SeaFest or Sopot Ocean Days (at least 4 in 4 countries). Local politicians will be invited to attend these events. At these events EuroSea will display its interactive exhibition and infographics, and a EuroSea YouTube channel will show the project video (WP8) as well as videos on ocean observing best practices, e.g. biological sampling, Argo deployment, modelling, etc. from the BP open online portal (WP1).
- **Seminars** will take place to engage with university students as the next generation of professionals in the ocean observing value chain, on the EuroSea and broader ocean observing challenges and opportunities (at least 4 in 4 countries). This will allow EuroSea to both contribute to training of young scientists as well as collect feedback and ideas from the future oceanographers who will help implement and benefit from the integrated ocean observing system delivered by the project.

2.2.5 Knowledge transfer and impact monitoring

The impact achieved by EuroSea will result in *knowledge transfer* towards innovation in the European ocean observing and monitoring in support of a sustainable blue economy and responding to policy needs. EuroSea will generate knowledge transfer through the following activities: 1) best practice and lessons learnt towards actionable and effective stakeholder co-design and technology transfer (**WP1,5,6,7,8**); 2) technology transfer towards commercially exploitable project results (**WPs 5,6,7,8**); 3) internal and external capacity building (**WP3,4,5,6,7,8**); 4) exploiting and enhancing science-policy and public-private interfaces (**WP1,5,6,7,8**); 5) influencing the next generation of professionals in the ocean observing value chain (**WP8**); 6) influencing public and policy by communicating on the importance of ocean observing for society, environmental policies and Blue Economy, along the Ocean Literacy principles (**WP8**). The **impact assessment** of the EuroSea communications will start from the outset of the project's activities. Impact assessment and monitoring will be delivered by **WP8** according to the impact protocol (Figure 6).



The impact evaluation will be both quantitative and qualitative. EuroSea **qualitative impact evaluation** methods will include direct interaction with the targets and users of the project's results, for example, through dedicated matchmaking or workshops for innovation users, meetings with port authorities or fishers. **Quantitative evaluation** will include website hits, number of references and comments on social media, numbers of participants at EuroSea webinars, media coverage, numbers of copies of printed materials disseminated, number of views of the EuroSea video, numbers of profiling events and exhibitions, etc.

3. Implementation

3.1 Work plan — Work packages, deliverables and milestones

3.1.1 Brief description of the overall structure of the work plan

EuroSea combines key actors of ocean observing and forecasting with key users of ocean information in an ambitious project focused around three demonstration activities (**WP5,6,7**) addressing ocean health, operational services and climate that integrates the full value chain of ocean observing, data assembly and analysis, and customized downstream services. The demonstration activities are supported by all work packages (WPs) ensuring crosscutting integration within the project. To implement the EuroSea vision of "*a truly interdisciplinary ocean observing system that delivers the essential ocean information needed for the wellbeing, blue growth and sustainable management of the ocean*", EuroSea is organized along nine interlinked work packages. An innovative aspect of EuroSea is the strong integration entered around the three demonstration projects.

3.1.2 Timing of the different work packages and their components

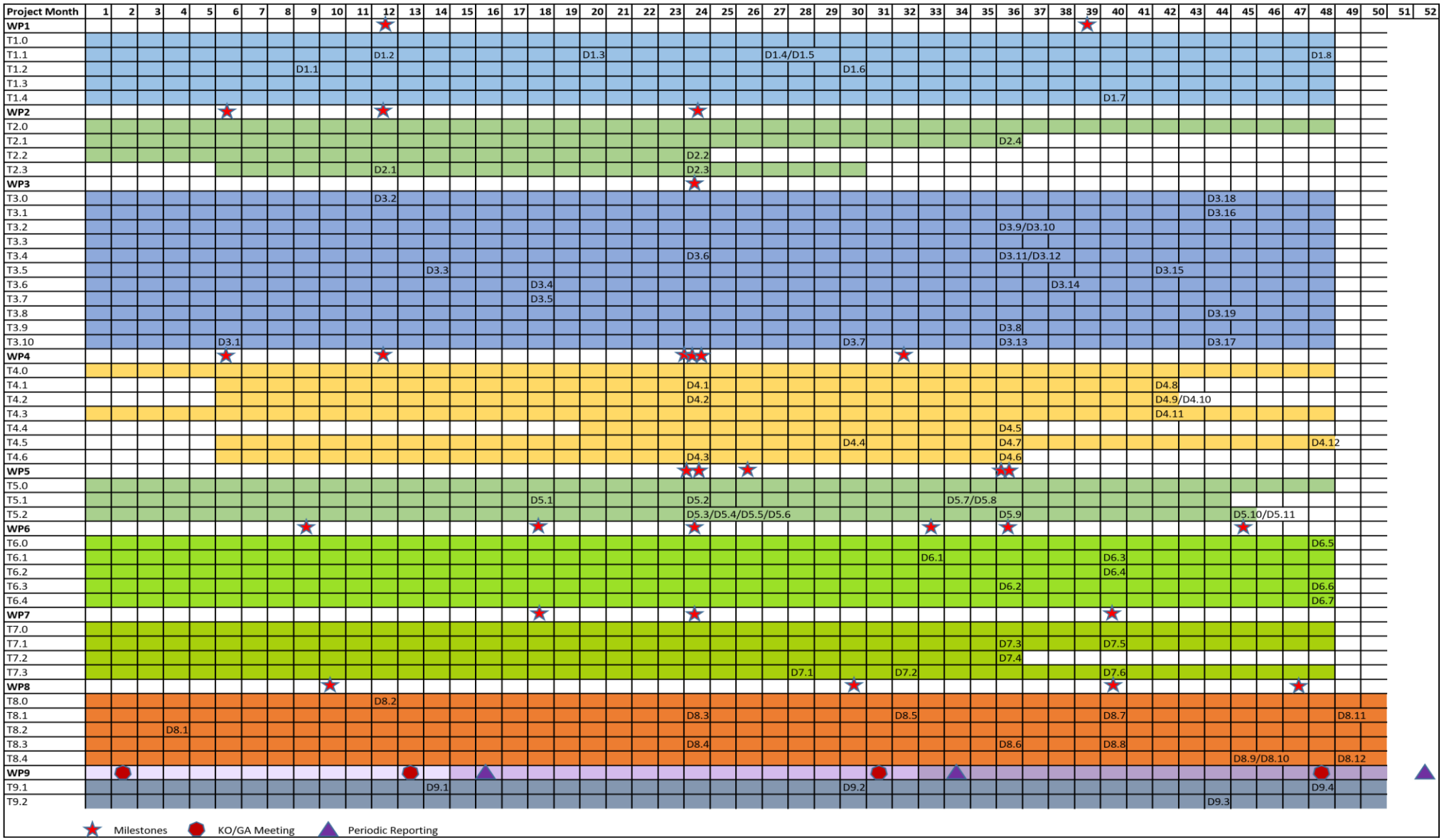


Figure 6: *Gantt chart of EuroSea activities.*

WP1 will provide the "European dimension" connecting EuroSea actions to an integrated observing system and will support coordination and governance on a European level (e.g. EuroGOOS and/or EOOS development) and connect with international activities (e.g. GOOS, JCOMM, OceanPredict, etc.). WP1 has a foresight and best practices coordination component. **WP2** will support the design of the observing system as a whole through Observing System Simulation Experiments, but also more directly towards the demonstration projects (**WP5,6,7**), the observing network integration and improvement (WP3), as well as data integration, assimilation and forecasts (WP4). WP2 will build on work done in H2020 RIA AtlantOS (633211) and complement gaps in design structures. **WP3** will ensure the concerted operation of European in situ ocean observing technology and will oversee key aspects of integration of observing technology for optimal use in European ocean observing considering national/commercial interests. WP3 will also foster the enhancement of existing best practices for methods and technologies. **WP4** will ensure that new or consolidated in situ observation data from different observing networks (**WP3**) and the demonstration projects (**WP5,6,7**) are integrated in the European modelling and forecasting systems at different space and time scales, from the Copernicus Marine Service global to the regional North East Atlantic and Mediterranean Sea systems. **WP5** provides a demonstration of the end-to-end connection from observations to their wider availability and use by stakeholders (e.g. ports and coastal cities) by combining and downscaling existing CMEMS and into novel decision-making tools and forecasts for policy and planning. **WP6** focus on linking oceanography and society through the co-development of science-based products in the context of ocean health. It will develop a shared understanding of water management among end-users in aquaculture, fisheries, tourism, environmental agencies and scientists by working together to co-create products that help to identify and foresee *"Extreme Marine Events"* threatening marine ecosystems, resources, and related businesses, and supporting adaptive management decisions. **WP7** addresses innovative ways to assess the role of the oceans and seas in the Earth's climate through the development, evaluation and dissemination of ocean climate indicators and their value for key end-users in economy (blue economy), societal (policy) and environmental sectors (climate science), i.e. the three pillars of sustainable development. **WP8** is dedicated to communication focused around four main tasks: Engagement, Dissemination, Exploitation, and Legacy, and will deliver critical support to the project and its demonstrators, assisting EuroSea in the delivery of viable and targeted outputs through stakeholder engagement and co-design. **WP9** will carry out the overall project management including support of integration of innovation, and interfaces with the other actions funded under the same topic.

3.1.3 Detailed work description

Table 3.1a: *List of work packages*

WP No	WP Title	LP No	Lead Participant (LP) Short Name	Person-Months	Start Month	End month
1	Governance and Coordination of ocean observing and forecasting systems	3, 2	IOC/UNESCO (Emma Heslop), EuroGOOS Glenn Nolan)	178	1	48
2	Ocean Observing System Design	7, 8	CSIC (Ananda Pascual), ENS (Sabrina Speich)	87.1	1	48
3	Network integration and improvements	33, 1	HCMR (George Petihakis), GEOMAR (Johannes Karstensen)	203.05	1	48
4	Data integration, assimilation, and forecasting	4, 5	MOI (Pierre Yves Le Traon), UNIBO (Nadia Pinardi)	227.8	1	48
5	Coastal resilience and operational services demonstrator	26, 23	UKRI (Kevin Horsburgh), EPPE (Enrique Alvarez-Fanjul)	130	1	48
6	Ocean health demonstrator	6, 7	MI (Caroline Cusack), CSIC (Javier Ruiz)	105.52	1	48
7	Ocean climate indicators demonstrator	4, 17	MOI (Karina von Schuckmann), IOPAN (Maciej Telszewski)	114.5	1	48
8	Communication: Engagement, Dissemination Exploitation, and Legacy	2, 1	EuroGOOS (Dina Eparkhina), GEOMAR (Anja Reitz)	86.4	1	50
9	Project Coordination, Management and strategic ocean observing alliance	1	GEOMAR (Toste Tanhua)	50.5	1	50
				1152.15		

Description of each work package (Table 3.1b)

WP No	**1**		**Lead beneficiary:**	**IOC/UNESCO, EuroGOOS**			
WP Title	Governance and Coordination of ocean observing and forecasting systems						
Participant No	1	2	3	15	17	25	26	35
Short name of participant	GEOMAR	**Euro GOOS**	**IOC/ UNESCO**	SOCIB	IOPAN	IEEE	EMB	Met Office
Person months per participant	36	48	54	4	20	3	8	5
Start month	1			**End month**	48			

Objectives:

- To support observing system coordination and governance both on international (e.g. GOOS, JCOMM, GCOS, G7, OceanPredict, and GEO) and at European level in supporting EOOS/EuroGOOS implementation.
- Deliver foresight into societal relevance, drivers and governance for ocean observation systems, new technologies and system sustainability.
- Strengthen the Ocean Observing system, with a focus on European needs, through extending the BioEco networks, monitoring of marine plastics, and supporting delivery for assessments, SDG indicators etc.
- Development of key components of EOOS structure and implementation of the GOOS 2030 Strategy.
- Step change in availability and identification of Ocean Best Practices.
- Support ocean observing status monitoring and visualization.

WP leader and co-leader: Emma Heslop (IOC/UNESCO), Glenn Nolan (EuroGOOS)

Description of work

Task 1.0 Coordination (EuroGOOS, IOC-UNESCO), PM1 - PM48

This task will coordinate the WP across its objectives and the four main work areas, and will track progress monthly with the task coordinators and verified quarterly via teleconference with all WP1 partners. The task includes coordination with GOOS, JCOMM and the connection to other regional ocean observing flagships in this Blue Growth Call (BG-08-2018-2019: All Atlantic Ocean Research Alliance Flagship, LC-BG-09-2019: Coordination of marine and maritime research and innovation in the Black Sea) and (BG-01-2018: Towards a Baltic and North Sea research and innovation programme, BG-05-2019: Multi-use of the marine space, offshore and near-shore: pilot demonstrators)

Task 1.1: Observing and forecasting system coordination, national, regional, global (task lead: EuroGOOS, partner: IOC-UNESCO), PM1 - PM48

Task 1.1 will support coordination of ocean observing at global, regional and national level for GOOS, EOOS, JCOM(M) and panel activities across European Seas. This task will directly support the development of EOOS, the enhancement and extension of BioEco and BGC sampling networks and connection to intermediate end-users across the European Seas, in line with the Draft GOOS 2030 Strategy and other governmental priorities, specifically those from the G7 WG "Future of Seas and Oceans". Regional, national and international connections will be strengthened, with focus on connection to national programs and intermediate users. Five subtasks are foreseen:

T 1.1.1: EOOS GOOS Implementation (task lead: EuroGOOS, partner: IOC-UNESCO), Deliverables D1.8:

Actively support the implementation of EOOS through the initiation of two of the governance structures; the EOOS Advisory and Operational Committees. These two committees involve intermediate end users and national ocean observing contacts (see EOOS Implementation Plan for details), and map directly to GOOS strategic objectives 1 and 2: Strengthening national contacts and partnership with key intermediate users to support the delivery of an integrated fit for purpose observing system. The development of the work of these committees will evolve through annual meetings. Pilot actions identified in the EOOS Implementation Plan will be tracked and reported upon.

T 1.1.2 Strengthen and extend BioEco monitoring networks throughout the European Seas (task lead: IOC/UNESCO), Deliverables D1.2, D1.4:

This task will strengthen and extend the BioEco networks throughout the European Seas, including data flow and establishing use of best practices and/or undertaking an EOV/network focused workshop on European Seas. More specifically: 1) develop global networks for ocean biology observations, including workshops to reach agreement on observation strategies, data sharing practices, and best practices and standards, and strengthening engagement with national and international research and observation programs; 2) deliver to the requirements of the European Marine Strategy Framework Directive (MFSD) related to conservation and sustainable use of marine biodiversity and ecosystems, support the European Ocean Observing System (EOOS); 3) map the current state of the networks that have a set of biological EOVs, 4) provide metrics that will advise EOOS, policy makers and managers on progress against a sufficiently sustained BioEco observing system and guide selection of targets and indicators against which performance can be measured for international conventions and assessments.

1.1.3 Developing capacity and coordination for a sustained ocean observations of marine plastic contaminants (task lead: IO PAN), Deliverables D1.5:
The task will bring together technical experts leading individual global observing networks with leading authorities focused on marine plastic contamination (e.g. GESAMP, UN Environment and initiatives involved monitoring, sensor development, and ecosystem impact assessments in marine plastics) with the aim to establish global coordination of sustained observations of marine plastic contaminants as a "Human Pressure" EOV. This subtask will establish a common sampling protocol, support implementation among European observing network partners, and establish the capacity to map out marine plastic contaminant monitoring.
T 1.1.4: Ocean Best Practices (task lead: IEEE, partner: IOC/UNESCO, SOCIB), Deliverables D1.3:
Overall, the task will improve discovery and access to the Ocean Best Practice System (OBPS). This subtask enables new ocean BP documents to be an integral part of the global (OBPS) and ensures that BPs identified by EuroSea from European programs and infrastructures (e.g. developed in the framework of MSFD) are accessible in the OBPS. The subtask will facilitate development and availability of new best practices from within the project through dedicated best practice sessions in two selected EuroSea workshops organized in conjunction with an OBPS Community Meeting. In addition, and through the workshops, a community approved BP template will be created with enhanced metadata profiles that will enable BPs that support delivery for societal applications (e.g. MFSD, SDG indicators) to be identified within the repository, using global ontologies. Through the Workshops and OBPS Community Meeting, this task will develop best practices within the demonstration activities.
1.1.5 Strengthening links to the leading edge of global forecast and prediction (task lead: MetOffice):
This task will link EuroSea with the international activities of OceanPredict (former GODAE Ocean View) task teams on Data Assimilation and Marine Ecosystem and Analysis. Planning meetings and 2 dedicated workshops will be held between EuroSea and OceanPredict to share project results, facilitate knowledge transfer and to explore synergy from ongoing complementary activities. This task will also explore the feasibility of uptake of outputs from EuroSea in an international data assimilation and ocean forecasting context. Through this task, stronger collaboration between the Coastal and Shelf Seas task team and the EuroGOOS coastal working group will be established.
Task 1.2 Observing system status monitoring (task lead: IOC-UNESCO), Deliverables D1.6: PM1 - PM48
This task will support JCOMMOPS to deliver observing system metadata, visualization and indicators across the European Seas. EuroGOOS/JCOMMOPS regional contacts will be selected to guide the inclusion of observing data not yet in the system (particularly coastal observations), quality control of metadata, development of indicators on status of the observing system by region and across EOVs. The initiative will start with Mediterranean Sea and expand out to the Atlantic and Global Ocean, building on the work undertaken within the AtlantOS Project. The data flow to European data infrastructures, such as EMODnet, will be monitored and optimized and the metadata vocabulary will be harmonized and connected to SeaDataNet services.
Task 1.3 Foresight (task led: EMB, partner: EuroGOOS, IOC-UNESCO, GEOMAR), Deliverables D1.1:
Building on previous and ongoing work in Europe and worldwide, this task will assess the current capability for conducting foresight related to ocean observation and the crucial role that foresight plays as part of a regular, iterative cycle of a coordinated and societally-relevant ocean observing system.
T 1.3.1: Identifying existing initiatives in foresight in ocean observation, emerging strategies and roadmaps (task lead: EMB):
Foresight is crucial to support decisions in a fit-for-purpose ocean observing system as it brings a forward look on the drivers and capabilities, the latest scientific knowledge and the technological feasibility in observing infrastructure. This task will identify existing initiatives, strategies and roadmaps that contribute to foresight in ocean observation.
T 1.3.2: Foresight workshop 1: Ocean technology, platforms and Artificial Intelligence (task lead: EuroGOOS, partner: EMB):
For Ocean Observing to be fit-for-purpose ocean technologies, platforms and new methods such as Artificial Intelligence (AI) need to be mapped and the links between new and established technologies need to be clear. To do so, the EOOS implementation plan proposes a Technology Forum that will enable old and new technologies to be compared for usefulness for the ocean observing system, to share data from these new technologies, and to provide guidance to technology developers to ensure a strong understanding of the user requirements for such technologies.
T 1.3.3: Foresight workshop 2: Sustainability of the Ocean Observation system (task lead EMB, partner: IOC-UNESCO):
Ocean observations are used in marine forecasts and increasingly play a significant role in weekly to seasonal weather forecasts, and other operational services. Thus, we need to find a way to recognize Ocean Observing as a valuable public utility, similar to the weather forecasts, pollen reports, etc. that we already obtain through national and international meteorological services. This task will investigate possible future mechanisms ("Ocean Office") to sustainably fund the ocean observations, modelling and predictions. This is needed not just for ocean weather, but

also for ocean geochemistry, biology and ecology, to enable societal benefit through *inter alia* food provision, human health, better predictions of storms, and many other applications, and will benefit from input from Task 1.4 (D1.3).

Task 1.4 Legal aspects of ocean governance and impact on the observing system (task lead: EMB, partner: GEOMAR), Deliverables D1.7:

Several legal frameworks exist that are important for countries conducting ocean observing activities or for which it would be relevant to include the necessity of ocean observing activities and development of ocean information products. Existing hard and soft law frameworks (e.g. UNCLOS, UNFCCC, CBD) and mechanisms (e.g. National Adaptation Plan process) will be analyzed to enable adequate adaptation of ocean observing system design at a regional and global level, with a focus on supporting sustained ocean observing and fit-for-purpose ocean information products - how can we use legal frameworks practically for the ocean observing system? What are the opportunities within the frameworks that we have to take into account? What are the gaps in the existing frameworks and how can they be closed? Initial results will be communicated to e.g. national authorities to get their feedback and develop a report that can serve as best practice document.

Deliverables

D1.1: Report on policies: Identifying existing initiatives in foresight in ocean observation, emerging strategies and roadmaps, PM9. **D1.2:** Map of BioEco Observing networks/capability, PM12. **D1.3:** Metadata standards demonstrator for Ocean Best Practices, PM20. **D1.4:** Report on European BioEco networks, metrics on progress against a sufficient sustained BioEco observing system, including for MSFD, PM27. **D1.5:** Define a marine plastics EOV and establish a common sampling protocol and demonstrate appropriateness among European observing network partners, PM27. **D1.6:** Maps and metrics on observing systems and metadata – (Mediterranean Sea, Atlantic, Baltic) for main in-situ platforms and networks, PM30. **D1.7:** Report on the use of legal frameworks for ocean observing systems, PM40. **D1.8** Final Report of EOOS Implementation Plan: Progress, function of systems and recommendations for EOOS, European OO and GOOS (GRAs etc.), from across the Work Package, PM48.

WP No	**2**		**Lead beneficiary:**		**CSIC, ENS**		
WP Title	Ocean Observing System Design						
Participant No	4	7	8	9	15	27	28
Short name of participant	MOI	**CSIC**	**ENS**	CLS	SOCIB	IMT	OceanNext
Person months per participant	15	18.2	25.7	14.7	5.5	4	6.4
Start month	1				**End month**	48	

Objectives

The overall objective is to apply the systems design processes of the *Framework for Ocean Observing* (FOO*)* on the EuroSea observing system in support of connected and integrated European Ocean Observing systems for the broader Atlantic Ocean and Mediterranean Sea. It builds on the H2020 AtlantOS achievements and take on its legacy to further develop them within the Galway and Belém agreements objectives. Specific objectives are:

- To define the high-level requirements of EuroSea based on the societal benefits, providing a direct link to societal challenges related to the larger Atlantic and Mediterranean basins and the European Blue Growth strategy. These requirements will be translated into strategic recommendations about sustained monitoring of EOVs and linked with LR7 and LR8 societal relevant indicators.
- To identify the requirements in existing observing networks in support of specific demonstrators (WP5,6,7).
- To deliver guidance to improve existing elements and/or implement new ocean observing components to EuroSea using various techniques, including OSSEs and data assimilation to optimally merge in-situ and satellite observations with models to provide accurate estimates for indicators.

WP leader and co-leader: Ananda Pascual (CSIC), Sabrina Speich (ENS)

Description of work

The work undertaken in WP2 will be in direct support of; the EuroSea demonstrator activities (WP5,6,7), the observing network integration and improvement (WP3), data integration, and assimilation and forecasts (WP4). The work will focus on verifying the EOVs and Indicators, analyzing the gaps of existing systems and possible upgrades [Task 2.1], carrying out system design studies [Task 2.2], [Task 2.3].

Task 2.0 WP coordination (CSIC, ENS), PM1 - PM48:

This task includes the coordination of the WP, interfaces between WP2 tasks and interfaces with other EuroSea WPs and GOOS panels and work plan. The work package leaders will ensure that the planned work is carried out according to plan and budget and that the deliverables are produced and milestones are attained on time. This task

will ensure the establishment of the link with EuroSea project coordination and that decisions taken at steering committee level are implemented, including management of risk and mitigation measures.

Task 2.1 Developing Indicators for observing system networks/Demonstrators (task lead: ENS, partner: CSIC), Deliverables D2.4, PM1 - PM36:

This task starts with the verification of the Essential Ocean Variables (EOVs) required to inform the major societal drivers of sustained ocean observing. We will then link Atlantic and Mediterranean indicators for climate (WP7), ocean health (WP6), and coastal resilience and operational services (WP5) into strategic recommendations about sustained monitoring strategies of the EOVs. The approach of the FOO will be used to define the critical requirements for EuroSea. Societal requirements will be expressed as the space-time resolution and accuracy required for sustained observations of the physical, biogeochemical, and biological EOVs defined by GOOS. These recommendations, including a strategy for the observing networks to monitor these EOVs, will be drafted from present knowledge early in the course project. We will later develop and deliver dedicated indicators (with related uncertainties) to EuroSea partners according to guidelines and end users, increasing the TRL of the EuroSea observing system through workshops, focused on specific indicators and pilots. In the last phase of the project, we will revisit the requirements and integrate the inputs gathered in this work package, and others, on the feasibility, readiness, and impact of the observing system in order to provide guidance on network design, and assess the adequacy of the observations against the developed indicators. The sustained observing requirements and network design will be revised, leaving a legacy of a better-integrated ocean observing system.

Task 2.2 Observing System Design Experiments with global ocean monitoring systems (task lead: MOI, partner: CLS, ENS), Deliverables D2.2, PM1 - PM24

The goal of task 2.2 is to deliver objective guidelines to improve existing elements and/or implement new components of the Atlantic and Mediterranean Sea Observing system. The general approach will be based on Observing System Design Experiments that rely on physical and biogeochemical models, or statistical techniques that realistically represent the space-time variability of the EOVs to be observed, both methods will be optimally merging in situ and satellite observations.

Following the work initiated during H2020 AtlantOS project, long time scales (e.g. 10 years) OSSEs (Observing System Simulation Experiments) will be developed to assess the role of regionally increased coverage of the Argo array, its extension to the deep ocean and tropical moorings in improving the accuracy of global CMEMS products and the derived ocean indicators. The analysis will focus on the uncertainty reduction thanks to improvements in situ network design of physical indicators, as defined in T2.1 and in WP7, for example the Heat Content and Sea Level estimates. The partners will follow common protocols (e.g. sharing the same reference model simulation, pseudo-observations and common diagnostics). The use of two different global ocean monitoring systems, a multivariate multi observation analysis system (ARMOR3D) and a data assimilative system (the Mercator Ocean global ocean forecast system) will give complementary information.

OSSEs will also be set up to refine the design of the BGC (biogeochemical) network extensions aiming at improving the accuracy of future global CMEMS BGC analysis and forecast system by complementing the satellite observations. The role of the BGC Argo and tropical mooring enhancement will be assessed, as well as their potential impact on the pH and pCO_2 estimates. The analysis of the OSSEs will focus on regions of interest for the climate demonstrators (subpolar North West Atlantic, Tropical Atlantic). Coordination with WP3 and the demonstrators will support the design of the experiment design, and the definition of assessment metrics.

Task 2.3 Observing System Simulation Experiments: impact of multi-platform observations for the validation of satellite observations (task lead: CSIC, partner: CLS, IMT, OceanNext, SOCIB), Deliverables D2.1, D2.3, PM6 - PM30:

Space borne and in situ observations provide essential and complementary information on fine-scale ocean structures. This task aims at improving the design of multi-platform observations for validation of high-resolution satellite observations (conventional nadir altimeter SWOT and SKIM) with the aim of optimizing the utility of these observing platforms. OSSEs will be conducted to optimize sampling from different configurations of the in situ observing system, including velocities from surface drifter, glider, Argo floats displacement at the surface, shipborne ADCP and current meters. Simulations from high-resolution models (NATL60, CMEMS, WMOP) will be used to simulate the observations and the ocean "truth" to represent fine-scale sea level and surface ocean velocities. Dedicated efforts will be devoted to error parameterization determination for each observing platform.

Several methods of reconstructions will be tested; the first method is a multivariate optimal interpolation mapping method using both satellite and in situ observations of height and velocities and prior statistical knowledge of the field to be estimated. It will allow first to validate the space borne observations and then to improve both the ocean surface currents and height and the geostrophic component of the circulation will be reconstructed as well as other components such as Ekman. Secondly, new algorithms of reconstruction of in-situ data using machine-learning techniques (neural networks, analogue methods) will be explored, implemented and benchmarked to be compared

with high-resolution satellite observations of height and ocean currents that will be simulated using SWOT and SKIM simulators. Finally, the 2-km resolution WMOP modelling and data assimilation system will be used to reconstruct multivariate 3D fields from these virtual observations. The capacity of the reconstructed fields to represent the sea level and surface current variability of the nature run at the scales and with the expected accuracy of the future satellite missions will be evaluated considering different configurations in situ observations.
The analysis will focus on two regions of interest for the Climate Demonstrator in WP7 (Subpolar North West Atlantic and Western Mediterranean Sea). Special attention will be devoted to the Southwestern Mediterranean Sea to include the crossover of the SWOT mission during the fast sampling phase. These OSSE will contribute to the design of the in-situ observing systems to support the future calibration and validation of high-resolution satellite measurements.
Input from WP3 will refine the work plan, but also when defining the assessment metrics, in coordination with the demonstrator activities (WP5,6,7) and T4.5 on validation of satellite products with multi-platform observations.

Deliverables

D2.1: Design of the Observing System Simulation Experiments with multi-platform in situ data and impact on fine-scale structures, PM12. **D2.2:** Analysis of the physical and BGC design experiments: impact of physical and biogeochemical observation network evolutions on CMEMS global analysis, PM24. **D2.3:** Analysis of the Observing System Simulation Experiments with multi-platform in situ data and impact on fine-scale structures, PM30. **D2.4:** Development and dissemination of targeted indicators and their uncertainties for demonstrators (WP5,6,7) and Forecasts (WP4), PM36 .

WP No	**3**		**Lead beneficiary:**			**HCMR, GEOMAR**						
WP Title	Network Integration and Improvement											
Participant No	1	6	7	10	13	14	15	19	20	21	29	30
Short name of participant	**GEOMAR**	MI	CSIC	OGS	UKRI	SU	SOCIB	Euro-Argo Eric	CNRS	IFREMER	AZTI	EPPE
PM per participant	2	5	5.6	5.5	6.4	4	24.5	4	21	6.2	14.5	14.5
Participant No	33	34	36	37	38	39	40	41	42	47	51	
Short name of participant	**HCMR**	NIVA	EMSO-Eric	PLOCAN	UBREMEN	UPORTO	SZN	AWI	ETT	CNR	WMO	
PM per participant	2	4	4	8	2	6	18	7	10	5.4	22	
Start month	1					**End month**	48					

Objectives

WP3 will oversee key aspects of integration of European observing technology for its optimal use in an EOOS and global initiatives (e.g. GOOS) and, in parallel, addressing national interests. The integration has two dimensions: **observing networks**, grouped around technology on platforms (mooring, tide gauges, glider, floats, ships, etc.), and **thematic networks**, grouped around a certain observing challenge (e.g. metagenomics, data, scientific issues).
Observing networks are aligned within tasks 3.1 to 3.7 and almost all (except task 3.7 - "Autonomous surface vehicles") are coordinated in either the EuroGOOS and/or GOOS/JCOMM framework. In WP3 we will ensure that most observing network reach TRL7 and defined as:

- Network coordinates a community of Best Practice around a specific technology
- Network specification and governance structure is articulated (e.g. Terms of Reference)
- Network data policy is defined and comply with FAIR principles (findable, accessible, interoperable, re-usable)
- Long term (>10 years) sustained observing needs are defined
- Networks are open to all operators of the respective observing technology
- Best Practices for each networks, addressing the EOV specification sheets, are documented and deposited at oceanbestpractices.org

One objective is improving internal coordination within the observing networks, guided by scientific/engineering expertise and supported by a technical coordinator. Another objective is interacting with the observing component in the EuroSea Demonstration activities (WP5,6,7) to, for example, proof Best Practice documentation (link to WP1) or data quality control and dissemination capacity is sufficient (task 3.10).
Thematic networks are grouped around the "observing networks" overarching challenges, and include observations that target potentially emerging EOVs (task 3.9 augmented observations), multiplatform optimal sampling (task 3.9) and data integration (task 3.10). Most, if not all, of the ocean observing objectives require the operation of a mix of

observing technology in order to capitalize on the observing platform specific space/time sampling, the available sensor payload, and the achievable data quality. The role of the thematic networks is to enable a dialogue between observing requirements and the underlying scientific approach and the technology framework that is coordinated by the observing networks. Task 3.11 will ensure data delivery according to standards including communication pathways between platform operators, observing networks and data centers.

WP leader and co-leader: George Petihakis (HCMR), Johannes Karstensen (GEOMAR)

Description of work

WP3 is dedicated to the increase efficiency and effectiveness of operation and use of in-situ ocean observing technology by improving and integrating observing networks and improve their coordination.

Task 3.0 Coordination (task leader: GEOMAR, HCMR), Deliverables D3.2, D3.18, PM1 - PM48:

This task will oversee the progress in the WP and makes sure the tasks are operating towards the main objectives. Assessments of the EuroSea observing network coordination teams will be performed at the beginning and the end of the project and recommendations for EOOS observing networks coordination will be provided.

Task 3.1 Argo (task leader: Euro-Argo Eric, partner: Ifremer, SU), Deliverables D3.16, PM1 - PM48:

The main objectives in EuroSea are to coordinate the development of the Argo extensions, deep - below 2000m (DEEP) and biogeochemical (BGC), in liaison with the Euro-Argo-Rise (Technology) and the ENVRI-FAIR (data interoperability) projects, and in close link with the Argo international network. Interoperability with other observations that acquire similar observations within the EOOS framework will also receive attention (with applications in WP7). This task will: (1) consolidate with Euro-Argo Eric Management Board DEEP and BGC operations strategy (Atlantic, MedSea) considering with input from CMEMS, EMODnet and the EuroSea demonstrator projects most critical weaknesses (applications and budget); (2) develop Best Practices for DEEP & BGC Argo operations and data management via workshops and WP7 feedback, and upload to OceanBestPractices.org; (3) support interested countries to engage with Argo in the Atlantic and Mediterranean Sea in partnership with Euro-Argo; (4) enhancement of the Euro-Argo Eric and international BGC, website/newsletters to highlight Euro-Argo ERIC progress in EuroSea.

Task 3.2 Underwater Gliders (task leader: CNRS, partner: WMO), Deliverables D3.9, D3.10, PM1 - PM48:

This task will support EOOS to develop a glider network that is in phase with the results of recent international programs (COST Action EGO; FP7 GROOM, H2020 AtlantOS), the EuroGOOS glider Task Team, and the G7 recommendations for gliders. The main objectives of this task are to improve glider coordination at the European level (providing a technical coordinator) though EuroGOOS and its ROOSes in particular, and to link them to the global activities in order to make them fully integrated in GOOS. Best Practices for glider operations (incl. EOV observations) and data management at the European and global levels will be created.

Task 3.3 Vessels (task leader: NIVA, partner: WMO), PM1 - PM48:

Ships of opportunity (SOOP; e.g., ferry lines, cargo ships) and research vessels (RV) are the two categories of ships used for ocean observing. The Ferrybox (FB) is a system for multi-variate observations on such vessels coordinated by the Ferrybox (FB) EuroGOOS Task Team. This task aims to improve SOOP & RV coordination in Europe by: 1) encouraging countries so far not involved to the EuroGOOS FB Task Team to join; 2) linking regional/global efforts (ICOS ERIC, SOCAT, JCOMMOCG-SOT); 3) re-evaluate/finalize Best Practices (in dialogue with SOT); 4) formulate Terms of Reference for the network; 4) provide cost assessments for operations, data management according to FAIR, and evaluation for game-changing technologies (autonomous sampling systems, nutrient analyzer/sensors, towed device technology). Dedicated workshops (European partners, SOT) and support for EuroSea demonstrator activities (T6.1, 6.2) will aid the process and the documentation. The European RV activities are not well coordinated (only tracked via SeaDataNet) and most RV surveys in Europe do not fit under the GO-SHIP (the global repeat hydrography program) Network. We will assess the need for a European-wide RV coordination, including updating best practices for operations and instruments where needed, and the readiness of the metadata management of RV operations (including GO-SHIP metadata management).

Task 3.4 Eulerian Observations (task leader: SU, partner: EMSO-Eric, WMO), Deliverables D3.6, D3.11, D3.12, PM1 - PM48:

Eulerian or fixed observatories record multidisciplinary time series data (biology, biogeochemistry, and physics) and addresses critical information on natural hazards, climate change and marine ecosystems and many others. The EMSO Eric (European Multidisciplinary Seafloor and water column Observatory) coordinates a number of sites in the northeast Atlantic, the Mediterranean Sea and the Black Sea while other European countries coordinate their observations via the OceanSITES JCOMM-OCG network (GOOS/GCOS frameworks). In this task we aim to improve harmonization between the EMOSO-ERIC and the global Eulerian observatory network (OceanSITES) in order to create a coherently coordinated European network of Eulerian Observations. Harmonization of metadata standards, Best Practices, and data quality control and archiving will be done and the network will be further opened

to new users and contributors (e.g. T3.8). Support for WP6,7 will be provided by the implementation of paired pH/O_2 sensors.

Task 3.5 European Sea Level Network. (task leader: EPPE, partner: UKRI, CNRS, MI), Deliverables D3.3, D3.15, PM1 - PM48:

Tide gauges are a critical tool for operational monitoring of coastal hazards, port operations and naval applications, but operation and maintenance that meet accuracy and latency requirements need further development. EuroGOOS established a Tide Gauges Task Team (TGTT) in 2015, to foster collaboration between national, regional and global sea level initiatives (GLOSS) and the CMEMS In-Situ TAC's.

EuroSea will support the establishment of an integrated European Tide Gauge Network as part of EOOS. Specific actions towards these objectives include two workshops that connects European and global communities (GLOSS, CMEMS), on the road-map and strategy, and on automatic quality control and processing (SELENE EPPE software) and new software modules for automatic control of levelling/reference (link to T5.1). We will: 1) improve metadata inventory of stations based on current user requirements, e.g. JCOMMOPS, CMEMS, Tsunami Warning Systems; 2) analyze gaps/duplicity in data portals providing tide gauge data and design a new strategy for data flow for tide gauge data storage, quality control and distribution; 3) assess/compile an on-line portal in PSMSL of uplift/subsidence land data, including new Multipath Reflectometry of land-based Global Navigation Satellite Systems (GNSS-MR) technology.

Task 3.6 HF Radar (task leader: AZTI, partner: CNR, SOCIB, EPPE), Deliverables D3.4, D3.14, PM1 - PM48:

The EuroGOOS HF Radar Task Team established in 2014 coordinates European activities around the development and use of the High Frequency Radar (HFR). This task will: 1) Enhance use of HFR surface current data and added value products; 2) Improve the availability of FAIR HFR data and implement Best Practices of HFR operations and maintenance; 3) Work towards a governance structure that ensures long-term sustainability; 4) Guide the development of the network with a prioritization performed at Sea-basin scale. Two workshops will be used to standardize quality assessment and data management (incl. defining additional QC for REP and added value products) and to improve HFR NRT and REP data applications and tools for added value products. Furthermore, the workshops will be used to: 1) promote the network coordination and establish a governance structure; 2) develop tools for supporting the advanced delayed mode QC of HFR REP and products and for inter-comparing model outputs and HFR products with a process-oriented approach; 3) implement an online reporting database, and to revise/complete Best Practices. Implementation of standardized NRT data flow through the EU HFR Node will be supported.

Task 3.7 Autonomous Surface Vehicles (task leader: PLOCAN, partner: UBREMEN, UPORTO, UKRI, Deliverables D3.5, PM1 - PM48:

Autonomous surface vehicles (ASVs) are unmanned platforms of increasing importance for multiple observing applications that are not coordinated on a European (EuroGOOS) or a global level. EuroSea will establish an ASV network for better coordination, technological innovation and best practices. This will improve the availability of ASV technologies at operational, data management and policy level, and will enhance the use of ASV data improving ocean observing products, their implementation and dissemination through existing EU data infrastructures. The specific actions towards these objectives are: 1) ASV-Network definition and roadmap addressed to cover current and future user's needs, including access to infrastructures, community roadmap monitoring, promoting knowledge exchange, enhancement and partnership worldwide with the establishment of an ASV User Group; 2) improvements on Standard Operating Procedures (SOP) for derived BP implementation on operational protocols, data management, knowledge transfer, risk assessment, legislation, etc. in order to properly improve the ASV technology, contributing to the EOOS implementation plan; 3) two workshops will be organized aiming at ASV technology - challenges, opportunities and user engagement, and ASV technology - Best-practices implementation. The tasks will cooperate and support the EuroSea demonstrator activities, in particular WP7 that will provide important feedback on ASV usage.

Task 3.8 Augmented Observatories (task leader: SZN, partner: AWI), Deliverables D3.19, PM1 - PM48:

Ocean health is inextricably linked to the integrity of its constituent ecosystems, and their potential to provide trillions of Euros in services to humankind. Recent advances in molecular methods such as genomic, transcriptomic, and related "omic" approaches show great promise in reporting on the state of, and change in, the omnipresent microbial foundations of marine ecosystems, which are intimately tied to ocean biogeochemistry. Marine omic observation has already detected responses to both anthropogenic and natural stressors and emerging networks of long-term, omically enabled observatories are beginning to realize the full potential of omic observation by global coordination of best practices, FAIR data products, and calibration actions with existing ocean observing infrastructures.

In this context, our objectives are to: 1) Develop and implement a set of standard operating procedures (SOPs) for long-term omic observation aligned to the GOOS EOVs (e.g. Microbial biomass and diversity) to augment well-established marine LTERs; 2) Leverage existing omic coordination networks (e.g. the Global Omics Observing Network: GLOMICON) to disseminate SOPs as exemplars of integrating long-term omics data into ocean observing and solicit international feedback; 3) Shape international standards to the needs of marine omics observatories; 4) Disseminate network-reviewed SOPs through the Ocean Best Practice System for formal review by the GOOS BioEco Panel to provide a firm foundation for future maturation of the omics observing community

The specific actions towards the objectives are: 1) an early workshop with international experts to align protocol development within the project with external activities and maximize global impact and synergy; 2) integrating input from WS1, testing omics SOPs through a 12 month implementation from global multi-omic surveys, adapted to an LTER setting; 3) engage the Genomic Standards Consortium to develop and update FAIR data standards for omic observing in marine settings, and the GOOS BioEco Panel to channel our activities into EOV development; 4) a workshop to consolidate progress and submit a formal recommendation to the GOOS BioEco Panel and all GLOMICON nodes on the use of omics in integrated ocean observing.

Task 3.9 Integrating science (task leader: SOCIB, partner: CSIC, AZTI), Deliverables D3.8, PM1 - PM48:

The rationale for this task is related to the need to have a multi-platform approach and associated strategies for combining observations and models to characterize and understand ocean state and variability at a variety of scales, from large basin scale to meso/submesoscale. We need integration to reach an overall common goal above each one of the elements: "*from egosystems to ecosystems*". The integration of multi-platform observations (e.g. T3.1-3.7) with numerical models is one key challenge today in ocean sciences given the importance of the well-established, platform driven ocean observing networks and forecasting initiatives (link to WP1,8). We need to connect the pieces of a N-dimensional ocean puzzle by integrating the different components of the observing & forecasting system (links to WP2,4) in order to add value of the integration, and to understand and predict ocean variability at all spatial and temporal scales, and across domains (physics, biogeochemistry, biology). The following objectives has been established: 1) establish a strategic, long-term vision for ocean integration to evaluate how changes in science and technology can be considered for sound integration of existing networks and platforms; 2) to develop tools for integration applied to EuroSea demonstrator activities (WP5,6,7) to achieve the requirements from EU Directives (e.g. MFSD implementation) in a more efficient way.

Consequently, the **actions** envisioned are: 1) **Develop a Strategic European Vision of Ocean Integration** by requesting relevant organizations in Europe for inputs on their approach to balance activities driven by network/platform/sensor/process with global/integrated/actions. A coordination body will be established to overlook the integration across observing networks that will channel and advance common strategies and response capacities. Workshops will be held, and the task will support establishing EOOS. **2) Ocean Integration in Ocean Health or Climate demonstrator:** Reliable 3d oceanic fields will be developed combining multi-platforms (in situ and remote) related to one demonstrator focusing on fine-scales, where KE and the associated 3D lagrangian pathways and exchanges between the upper ocean and the interior are enhanced. Integration will be also achieved though the different networks linking large scale variability with shorter spatial and temporal scales by this responding to state-of-the-art scientific priorities and society needs, in particular to MSFD requirements. Coordination with observation/network experts (WP1,3) will be ensured to refine the work plan in coordination with the observing system evaluation experiments (WP2) and the demonstrators (WP5,6,7).

Task 3.10 Interface with In Situ data integrators (task leader: IFREMER, partner: ETT, OGS), Deliverables D3.1, D3.7, D3.13, D3.17, PM1 - PM48:

Close collaboration with the observing network operators and data managers are essential to be able to ingest ocean data in the CMEMS and EMODnet products with an acceptable level of metadata and homogeneous quality. The main objective is to ensure that EuroSea new or consolidated data sets (physics, biogeochemistry) will be ingested in the Copernicus Marine Service and EMODnet portfolios as an essential step to make sure data feed Copernicus modelling and data assimilation systems, downstream coastal forecasting systems and EOV assessment.

The specific actions towards the objectives are: 1) Integration in CMEMS and EMODnet will be achieved by harmonizing work flow between the observing networks and the integrators through interoperable interfaces based on existing, international standards following up on the recommendations issued within the AtlantOS project. 2) The EuroSea observations from network data centers will be provided to the European and international marine and ocean data management infrastructures: Copernicus in situ TAC, EMODnet-Physics and EMODnet-Chemistry using tools previously developed by the integrators. Additionally, value-added services, like visualizations will be demonstrated.

Deliverables

D3.1: The Data Management Plan (DMP) in compliance with the guidelines given on data management in the Horizon 2020 Online Manual, PM6. **D3.2:** Report on assessment of the EuroSea observing network coordination,

PM12. **D3.3:** Report on agreed new strategy of data flow for tide gauge data storage, quality control and distribution, PM14. **D3.4:** Governance structure and roadmap of the HF Radar Network, PM18. **D3.5:** Report on ASV-Network structure and roadmap, PM18. **D3.6** Implementation of pH sensor on Eulerian observations in the Mediterranean Sea, PM24. **D3.7** Report on data harmonization recommendations for WP3 networks, PM30. **D3.8:** EuroSea guidelines for a Strategic European Vision of Ocean Observing Integration, PM36. **D3.9:** Report on European glider coordination (Best Practices, OceanGlider, metadata and data management), PM36. **D3.10:** Progress report on Glider metadata management, PM36. **D3.11** Upgrade Best Practices for fixed observatories in term of data processing (WS1 and WS2), PM36. **D3.12:** Metadata catalogue for fixed observatories including updated EMSO observatories information and OceanSites observatories through JCOMMOPS, PM36. **D3.13:** EuroSea data handbook, PM36. **D3.14** Innovative Tools for supporting the HF radar community (outage reporting, reprocessing historical data, model assessment), PM38. **D3.15:** New tide gauge metadata catalogue, PM42. **D3.16:** Euro-Argo updated strategy for DEEP and BGC development in Atlantic and Med Sea including implementation cost and Best Practices, PM44. **D3.17:** Report on ocean integration in EuroSea, PM44. **D3.18:** Observing Networks Final Assessment, PM44. **D3.19:** Standardized community protocols for long-term omics observing archived in the UNESCO/IODE Ocean Best Practices System and bearing on the GOOS Microbial EOV, PM46.

WP No	**4**	**Lead beneficiary:**			**MOI, UNIBO**		
WP Title	Data integration, Assimilation, and Forecasting						
Participant No	1	4	5	7	9	10	11
Short name of participant	GEOMAR	**MOI**	**UNIBO**	CSIC	CLS	OGS	CMCC
PM per participant	12	27.5	43	12.2	10.6	15	25.5
Participant No	12	14	15	16	29	30	31
Short name of participant	UiB	SU	SOCIB	ECMWF	AZTI	EPPE	ACRI
PM per participant	15	1.5	20	12	6	18	9.5
Start month	1				**End month**	48	

Objectives

The objective of WP4 is to ensure that new or consolidated in-situ observation data sets from the different networks (WP3) and from the WP5,6,7 demonstrator activities are integrated in the European modelling and forecasting systems at different space and time scales, from the Copernicus Marine Service global to the regional North East Atlantic and Mediterranean Sea systems. Ensemble forecasting at regional level will be implemented specifically to extract Extreme Forecast Indices (EFI) to connect with WP5 and WP6. In situ observations will also be used to produce new carbon EOV synthesis products. Finally, the skill of ocean variables from the Copernicus Climate Change seasonal forecasting systems will be assessed using observables ECVs to develop and provide user-relevant indicators in WP2 and WP7. All new products, observational and model data, will be integrated in the Copernicus Marine Environment Monitoring Service and the Copernicus Climate Change System thus reaching TRL7 and 8.

WP leader and co-leader: Pierre-Yves Le Traon (MOI), Nadia Piardi (UNIBO)

Description of work

Task 4.0 WP coordination (task leader: MOI, partner: UNIBO), PM1 - PM48:

The task deals with the coordination of the different tasks, the organization of the interfaces with other WPs, the organization of technical WP4 and cross-WP technical meetings and the relative reporting. Furthermore, the task participants will contribute to the project reporting as specified in WP8.

Task 4.1 Assimilation in the global and North East Atlantic (IBI) Copernicus Marine modelling system and analysis/forecast quality assessment (task leader: MOI, partner: EPPE), Deliverables D4.1, D4.8, PM6 - PM42:

An assessment of the impact of observations from the WP3 networks and from WP5,6,7 demonstration activities for the global and North East Atlantic (IBI) Copernicus Marine modelling and data assimilation systems will be carried out. The work will be based on future versions of the Copernicus Marine Service systems. Data assimilation techniques will be refined/adapted to best use physical and biogeochemical observations considered in EuroSea (e.g. DEEP and BGC Argo). Assessments from the global system will include both physics and biogeochemistry (incl. carbon cycle). Assessment from the regional (IBI) system will be focused on physics. Observations (e.g. tide gauges, HF radars, and gliders) will be used both for assimilation and for model validation. The task will also provide recommendations for the long-term evolution of the observing system.

Task 4.2 Assimilation in the Mediterranean Sea Copernicus Marine modelling system and analysis/forecast quality assessment (task leader: CMCC, partner: OGS, SOCIB), Deliverables D4.2, D4.9, D.10, PM6 - PM42:

We will assess the impact of the assimilation of glider and float physical observations from WP3 networks in the future versions of the CMEMS Med-MFC modelling and data assimilation systems. Impact of physical assimilation on biogeochemistry will be assessed using the CMEMS Med-BIO system. In addition, parallel data assimilation experiments will be performed in the SOCIB WMOP modelling system, a 2-km Western Mediterranean regional ocean circulation model downscaled from CMEMS Med-MFC (D4.7). The same glider and float observation dataset will be assimilated in both systems to evaluate their impact in two different ocean modelling frameworks. This will support understanding of the potential influence of the data assimilation approach and model resolution. Starting from a prototype of BGC-Argo float data assimilation, data assimilation experiments will be performed using the CMEMS Med-BIO system and BGC-Argo float data. The objectives are to evaluate the impacts of multivariate BGC-Argo float observations on the biogeochemical CMEMS products and to provide suggestions for the evolution of the BGC-Argo observing system. A multivariate covariance framework for increasing the spatial influence of the BGC-Argo network in the Mediterranean Sea at the basin scale will be used to support feasibility tests of biogeochemical assimilation of glider observations. Impacts of observations on the products from WP5,6,7 will be provided.

Task 4.3 Model development and validation for improved forecasting (task leader: UNIBO, partner: SOCIB, CMCC), Deliverables D4.11, PM1 - PM48:

In this task we will develop an operational implementation of an ensemble forecasting system for the CMEMS Med-MFC, producing products for the two demos in WP5,6. The ensemble forecast will be based on the methods already developed (TRL4) but not set operational and used by the demo developed in this project. Gliders, HF radar and drifter observations will be used in addition to Argo and satellite data to evaluate the spread of ensemble predictions in view of the observed 3D variability. Comparisons between the ensemble spread and model-data differences will allow to calibrate the ensemble to provide reliable estimates of model forecast uncertainties in terms of temperature, salinity and surface velocities. Several indices will be extracted, such as the ensemble-based Extreme Forecast Index (EFI) for sea level and waves (WP5), temperature and salinity (WP6) at the surface, in the water column and at the bottom. The EFI will be done both to map the likely occurrence of extreme conditions in different parts of the Mediterranean Sea with uncertainties from the ensemble analyses and the 3, 5 and 10 day forecasts.

Task 4.4 Improving the use of in-situ observations for the long term validation of satellite observations (task leader: CLS, partner: CSIC, AZTI, ACRI, SU), Deliverables D4.5, PM20 - PM36:

In situ observations are essential for the calibration and validation of satellite observations. Calibration activities organized by satellite agencies rely on dedicated instrumentation, whereas validation activities rely on the global ocean observing system. This task will demonstrate the potential of emerging in-situ networks for these activities. First, we will focus on the role of the BGC Argo array for the validation of ocean color satellite missions (in particular S3A&B) for Chl-a, particulate backscattering coefficient (bbp) and diffuse attenuation coefficient. The task will also consider the joint use of Argo, gliders, HF radars, surface drifters and tide gauges data for the validation of S3A&B SAR altimeter observations and the future SWOT swath altimetry mission in terms of sea level and currents. Seasonal and regional analysis will focus on regions of interest for WP7 as well as in coastal areas of the South East Bay of Biscay and South West part of the Balearic Sea where HF radars are available, making the link with WP5. Coordination with observation/network experts (WP3) will also be ensured to refine the work plan but also when defining the assessment metrics, in coordination with the demonstrator projects (WP5,6,7).

Task 4.5 Synthesis product development based on ship-based in situ biogeochemical data (task leader: UiB, partner: GEOMAR), Deliverables D4.4, D4.7, D4.12, PM6 - PM48:

Existing EOV synthesis products from in situ biogeochemical observations and high quality and long-term ship-based time series data will be fused to obtain optimal estimates of EOVs and derived quantities in support of ocean climate and ocean health monitoring. This task will focus on the EOV Inorganic Carbon with its sub-variables and on how to operationalize data flow and availability. Partner GEOMAR's main tasks will be to develop quality control procedures for data from certain platforms e.g. ship-based time series stations and partner UiB will integrate those quality controlled data with GLODAP. Partner UiB will operationalize European SOCAT and GLODAP quality control efforts and test the implementation of the quality control routines for ship-based time-series (TS) EOV data developed by GEOMAR. TRL for existing products will be enhanced from level 5 to 7, whereas the time-series pilot product will be enhanced from TRL4 to TRL6.

Task 4.6 Quality assessment of ocean variables from the C3S seasonal forecasts (task leader: ECMWF, partner: CMCC), Deliverables D4.3, D4.6, PM6 - PM36:

Knowledge of forecast skill is a prerequisite for utilizing forecast information. Assessing the skill of ocean variables from seasonal forecast has remained elusive due to the lack of verifying ocean datasets of sufficient quality and

length. This task will use improved climate records of Ocean Heat Content (OHC) from the CMEMS GLO-RAN ensemble and CMEMS regional centers (MFCs), the SLA ECV distributed by the Copernicus Climate Change Service (C3S), and the new SST records from ESA-CCI, to validate seasonal forecast of ocean variables. These new records will allow assessing the quality of ocean variables of the seasonal forecast contributing to C3S, A set of user-relevant climate and ocean indicators, defined by WP7, will be derived from the ensemble of seasonal forecast.

Deliverables

D4.1: Design of experiments to be conducted and update of the data assimilation systems (global/IBI), PM24. **D4.2:** Design of experiments and update of the data assimilation systems of the Med-MFC and SOCIB systems, PM24. **D4.3:** Compute probabilistic user-relevant climate indicators as specified by WP7 using ocean ensembles of seasonal forecasts, PM24. **D4.4:** Manual of operational implementation of Temperature and salinity QC, PM30. **D4.5:** Impact of EuroSea observations and recommendations for the observing system evolution, PM36. **D4.6:** Use CMEMS/C3S observation derived ECVs/EOVs to verify the ocean output from C3S seasonal and forecasts, PM36. **D4.7:** Manual of operational implementation of SOCAT QC, PM36. **D4.8:** Impact of EuroSea observations and recommendations for the observing system evolutions, PM42. **D4.9:** Intercomparison of skill scores of forecast and analyses for the two different assimilation and model systems in the Med Sea, PM42. **D4.10:** Impact of BGC Argo assimilation on the analysis and forecast quality of Med-BIO and evaluation of physical glider assimilation on biogeochemistry, PM42. **D4.11:** Definition and implementation of Extreme Forecast Indices and evaluation of effectiveness in WP5,6, PM42. **D4.12:** Manual of operational implementation of GLODAP QC, PM48.

WP No	**5**	**Lead beneficiary:**			**UKRI, EPPE**		
WP Title	Coastal Resilience and Operational Services Demonstrator						
Participant No	11	13	30	32	43	44	49
Short name of participant	CMCC	**UKRI**	**EPPE**	ARUP	Nologin	UPC	UCAM
Person months per participant	14	26	23	12	22	20	13
Start month	1				**End month**	48	

Objectives

The Work Package provides a demonstration of the end-to-end connection from observations - including a new generation of multi-parametric monitoring station - to their wider availability and use by a wide variety of stakeholders by combining and incorporating existing CMEMS and satellite products into novel decision-making tools for policy and planning. The Work Package also contains tasks dedicated to the development of new coastal management products which includes the downscaling of ocean analyses and forecasts for port and adjacent cities' operations aiming to:

- Provide an end-to-end demonstrator for climate quality sea level measurement to sea level services with a focus on the Mediterranean, but linked with Africa
- Development and demonstration of integrated observations and models supplying oceanographic services for ports and cities.

WP leader and co-leader: Kevin Horsburgh (UKRI), Enrique Alvarez-Fanjul (EPPE)

Description of work

Task 5.0 Coordination (UKRI, EPPE), PM1 - PM48

This Task will ensure the engagement with all stakeholders, coordinate interactions between the various strands of the Work Package, and oversee delivery (including to stakeholders). The Task will manage the coordination with and delivery to other WPs within the program.

Task 5.1 Sea Level Advice Demonstrator (SLADE)

The Sea Level Advice Demonstrator (SLADE) will accelerate capabilities for making informed decisions about sea level changes, initially for Europe but with the potential for the tools to become the global standard. This WP will advance current capabilities from the observations (tide gauges and satellite altimetry), through the data processing (automatic quality control, rapid and automated trend analysis) to a set of new decision-making frameworks designed around user needs. This WP will also develop a consistent approach for combining sparse tide gauge data with satellite altimetry in order to deliver a spatially complete picture of sea level changes. The geographical focus would be the Mediterranean Sea as a perfect test bed since it experiences sea level changes on all time scales. Sea level data from the WP will address the inhomogeneous coverage currently observed by MonGOOS.

T5.1.1 Low cost and maintenance free tide gauges (task leader: UKRI, partner: EPPE), Deliverables D5.7, PM1 - PM36:

We will prototype a new standard of multi-parametric monitoring station, designed around a new low-cost and largely maintenance-free tide gauge system powered by renewable energy. The new system will monitor both land motion and sea level, using novel techniques. This will be coupled with automated data processing in order to distribute near-real-time climate quality sea level data at minimal cost. The development of new, self-levelling, renewables-powered tide gauges would address some of the concerns of low data volumes from the African and Aegean areas. The system will be tsunami-capable, collating 1-minute integrations of 1-second samples, which will made freely available via the Global Telecommunications System (GTS). The new design will meet the GLOSS standards for measuring vertical land movement by exploiting a new technology known as GNSS multipath reflectometry (GNSS-MR), which allows the measurement of mean sea level whilst simultaneously measuring vertical land movement. There is potential to advance these technological solutions via the GLOSS community as a global standard. Apart from sea level, the station will have the flexible capability of monitoring atmospheric pressure, visibility, lightning and other variables. The locally implemented versions will depend on the specific requirements for each site. This work accelerates the harmonization and optimization of coastal sea level measurements in WP3.2

T5.1.2 Optimization of combined tide gauge data and satellite altimetry (UKRI), Deliverables D5.2, D5.8, PM1 - PM36:

This task will combine the tide-gauge data with fields of coastally re-tracked satellite altimetry to yield reconstructed sea-level fields with the same spatial coverage as the altimetry data and spanning the same period as the tide-gauge record. The new reconstruction will be analyzed in combination with CMEMS models with the aim elucidating the key drivers of sea-level variability. This information will then allow us to remove the known parts of the variability yielding trend estimates with reduced uncertainty. The end product will be a system that provides continuous updates of more accurate sea level trends and variabilities in the Mediterranean Sea. This data will feed the visualization and decision tool in T5.1.3 and connects to the data integration for multi-hazards forecasting in WP4.

T5.1.3 Data-driven modelling and visualization for sea level guidance (task leader: ARUP, partner: UCAM), Deliverables D5.1, PM6 - PM44:

This Task will design a new approach to modelling the interactions between sea level hazards, economic activity and risk. We will develop and demonstrate a novel approach to investment planning. The main aim of the method would be to provide a more robust approach to decision making under the high degree of uncertainty present in current sea level rise projections. The method would be based on aggregation of data from the previous, related tasks and pre-existing data sets, either static or dynamic. The approach would leverage recent technological developments in probabilistic modelling and economic appraisal methods, which have not yet seen widespread use in flood defense planning. The TRL advance would be evidenced by case studies demonstrating the potential for better coastal resilience decisions in the management of future sea level rise. We will demonstrate the pull-through of data in a number of policy/industry-led applications of the new method. At least one of these case studies will be in an African country. The output of this Task will directly contribute to WP7 in the context of new, user-relevant products for ocean climate monitoring (where sea level is a key variable) in support of risk management.

Task 5.2 Oceanographic services at the service of ports and cities (OSPAC)

This demonstrator will create an integrated set of tools and measuring instruments that will provide an operational service to the city and the adjacent port in order to minimize risks and improve environmental management. The Task will work directly with Barcelona, Taranto and Alexandria. The products and services will provide several socio-economic impacts and benefits, such allowing the control of water quality inside the port, providing a tool for management of the beaches to the town, and a tool to manage accidents such as oil spill. The following problems, amongst others, will be mitigated by the demonstrator: 1) water quality: coastal water quality depends on the activities of neighboring cities, ports and beaches, as well as in coastal circulation; 2) navigation safety in the environment of cities and ports; 3) beach safety, e.g. rip current forecasts and sea state monitoring and forecasting

T5.2.1 Model downscaling (task leader: UPC, partner: UPC, CMCC), Deliverables D5.3, D5.4, PM1 - PM36:

High-resolution operational forecast systems for wave, sea level, sea surface temperature, and circulation will be developed at all test sites. In all cases, and for all variables, the output resolution will be in the order of meters. The open boundary conditions for the forecast systems will be provided by the CMEMS systems. Atmospheric forcing will come from national Met-offices. Results of the models will be made available every day in an OPeNDAP system, so further third-party application could be developed in the future. The models will be validated with already existing instrumentation at the test sites, and with the instruments deployed to be deployed in task 5.2.2. The systems will run on daily basis at Puertos del Estado and CMCC facilities, and the results will be exploited by the OSPAC software system (task 5.2.3). This Task connects to the data integration for multi-hazards forecasting in WP4.

T5.2.2 Instrumentation deployment at test sites (task leader: UKRI, partner: EPPE, CMCC), Deliverables D5.9, PM1 - PM36

The novel multi-parametric equipment developed in task 5.1.1 will be implemented at the test sites. Final configuration will depend on site requirements. For example, at Barcelona, meteorological, visibility sensors and lightning detectors (to support safety during flammable liquid operations) will be implemented. All the real time data will be integrated in the OSPAC software and used for multiple purposes, e.g. real time alerts, model validation, monitoring of conditions for operations.

T5.2.3 OSPAC software development (task leader: Nologin, partner: EPPE, CMCC), Deliverables D5.5, PM1 - PM36:

The new OSPAC software, to be used by Port and City authorities, will have the following capabilities: 1) real time alert based on the monitoring stations deployed at task 5.2.2; 2) provide a forecast of the sea-conditions at the Port and the city in the following days, and link it with an alert system based on SMS and e-mail; 3) forecast of rip currents at the city beach. The operational prediction of these currents, including shore parallel (alongshore) and shore perpendicular components (undertow and rips), will be carried out through a hybrid system (bulk formulations plus numerical models) for at least two city beaches; 4) flushing times forecast for each Port and its docks: The methodology applied will be based on the numerical release of a Eulerian conservative tracer; 5) floating debris (including plastics) forecast tool for city and Port. Results from 5.2.1 will be used by a Lagrangian transport model in order to estimate the trajectories of debris. The simulated debris dispersion and advection patterns will be used by the port and the city to discuss impacts and recovery policy; 5) Flood and erosion risk forecast at the city beach, coastal flooding and erosion will be operationally forecasted by means of an open source morphodynamic numerical model.

T5.2.4 Demonstration of the tools at two European sites (task leader: EPPE, partner: UKRI, CMCC, Nologin), Deliverables D5.10, D5.11 PM36 - PM42:

During the last 6 months of the project, the system will be optimized and intensively tested in full cooperation with the users (port and City). The OSPAC software will integrate the data from the monitoring instrumentation and forecasts systems, providing service to final users.

T5.2.5 Demonstration of the tools at a non-European site (task leader: EPPE, partner: UKRI, CMCC, Nologin), Deliverables D5.6, PM36 - PM42

For the case of the African test site, this will be complemented by a capacity building activity in order to provide sustainability to the system. The capacity building will be based on supporting two visits of two local technicians to acquire appropriate skills for the installation and maintenance of the station and the operation of the software.

Deliverables

D5.1: Prototype seal level planning and scenario visualization tool, PM18. **D5.2:** Mediterranean sea-level reconstruction spanning 1950-2017, PM24. **D5.3:** CMEMS downscaled circulation operational forecast system for the three sites, including documentation on architecture and validation of the system, PM24. **D5.4:** CMEMS downscaled wave operational forecast system for the three sites, including documentation on architecture and validation of the system, PM24. **D5.5** Final version of the software running operationally for the demonstration, M24. **D5.6:** Documentation associated to the capacity building. PM24; **D5.7:** Automated tide gauge data quality control software and report. PM34; **D5.8:** Mediterranean sea-level trend and acceleration estimates with reduced uncertainty and toolbox for automated recalculation, PM34. **D5.9:** Operational monitoring systems available at the three sites, PM36. **D5.10:** Final report describing the demonstration and the user feedback at non-European site, M45. **D5.11:** Scientific model validation report during the demonstration period, PM45.

WP No	**6**	**Lead beneficiary:**			**MI, CSIC**		
WP Title	Ocean Health Demonstrator						
Participant No	3	6	7	15	45	46	50
Short name of participant	IOC/UNESCO	**MI**	**CSIC**	SOCIB	DMI	TalTech	Xylem
Person months per participant	0.00	28.43	35.19	6.20	13.00	20.00	13.72
Start month	1				**End month**	48	

Objectives

The overall objective is to develop a shared understanding of water management among end-users in Aquaculture, Fisheries, Tourism, Environmental Agencies and Scientists by working together to co-create products that help to identify and foresee *"Extreme Marine Events"* threatening marine ecosystems, resources, and related businesses, and supporting adaptive management decisions.

Specific objectives are to:

1. Demonstrate the value of ocean observing and forecasting of "*Extreme Marine Events*" at local to regional scales by developing downstream products and services to assess marine ecosystem health, and provide an early warning system to support sustainable Blue Growth industries and food security needs.
2. Provide a new perspective for environmental managers and policy makers focused on maintaining healthy marine ecosystems in harmony with human activities supporting stronger local and regional governance by using EuroSea decision support tools to assess ocean health.
3. Support the sustainable development of ocean observing and forecasting systems to monitor ocean health by stimulating international ocean observing initiatives.
4. Create new market and management opportunities for the private sector by co-creating new ocean products for aquaculture and fisheries.

WP leader and co-leader: Caroline Cusack (MI), Javier Ruiz (CSIC)

Description of work

Task 6.0 Coordination and Co-development (task leader: MI, CSIC, partner: all, including collaborators), Deliverable D6.5, PM1 - PM48

Coordination activities in WP6 will include the collection and review of partner contributions, ensuring timely reporting, and integration of activities with all EuroSea WPs and delivery and exploitation of developed EuroSea *in-situ* observing monitoring stations, downscaled models and improved services and products. We will facilitate good communication internally and externally to ensure work is carried out effectively in the timeframe given. We will monitor the risk and innovation of task activities and the quality of outcomes and take corrective action to mitigate potential deviations from impact. We will carry out regular co-development engagement activities with stakeholders in collaboration with WP8 and other WPs to facilitate a two-way free flow of communication (internal and external to EuroSea). Working with WP1 and 8, we will explore and expand the network of end-users, interest groups and connect and engage with international initiatives.

Task 6.1 "*Extreme Marine Events*" Ocean Observing & Forecasting (task leader: MI, partner: CSIC, SOCIB, IOC-UNESCO), Deliverables D6.1, D6.3, PM1 - PM48

In collaboration with WP3,4,7, and our co-developers, this task will use EuroSea capabilities to identify local and regional impacts of oxygen, heat and pH related "*Extreme Marine Events*" and develop bespoke mapping and forecasting products for industry, government and scientific customers (e.g. Mowi, CTAQUA, INCAR, BIM, NPWS, EPA). EuroSea activities will ingest, maintain, exploit, and develop ocean *in-situ* data and downscaled operational forecast numerical models to produce real-time and 3-day modelled forecasts of extreme marine events at aquaculture sites in the NE Atlantic (Irish waters) and W Mediterranean (Alborán Sea). In consultation with co-developers, the data products will be merged with existing marine biological datasets (WFD, MSFD, and MPA) and associated target organism vulnerabilities identified. Model hindcasts will be performed and results evaluated against observations (WP3, T6.4). A EuroSea transferable framework will be documented and shared with co-developers and the wider community. This task will also connect WP4 with the co-developers to exchange knowledge and identify additional science-based data products that could enhance day-to-day activities for industry and environmental managers. International cooperation will be initiated by co-funding an IOC-SCOR GlobalHAB/GESAMP science-stakeholder engagement meeting focused on Atlantic *Sargassum* biohazard issues to bring all parties together to: 1) determine what expertise, products and services already exist concerning this kind of harmful algal blooms; b) identify the knowledge gaps and research needed; c) assess solutions to help with this growing issue enabling new partnerships and ocean observing initiatives beyond EuroSea.

Task 6.2 Connecting CMEMS and fishery communities to increase uptake, and inform development of products for fishery management (task leader: CSIC, partner: MI), Deliverables D6.4, PM1 PM48

This task is a demonstrator with immediate application and a prototype to translate to other fisheries. By cutting across the disciplinary boundaries of CMEMS and fishery advice, data products from the EuroSea value chain will be exploited to support fishery management decisions leading to a better understanding of environmental pressures on exploited fish populations. Since physical and BGC numerical model outputs can help to better understand fish habitats, the data products in this task will underpin fishery advice to sustainably manage short-living, low trophic level, high biomass fish species. In particular, this is critically needed for the European anchovy and sardine fisheries with a recent call for action to guarantee sustainability, and to help end the social and economic emergency in European waters. This demonstrator will increase the uptake of existing CMEMS products in support of the Blue Economy, using existing investments to create new products where biological, economic and environmental drivers are integrated. The task will: 1) assess the benefits of existing CMEMS products so they can be considered for use by the ICES Working Group on Anchovy and Sardine (WGHANSA) and identify future ICES requirements to inform product development by CMEMS; 2) improve the advice to fishery managers, in support of Blue Growth, to enable the sustainable fisheries of small-pelagic species in European waters in a changing environment; 3) create new forms of collaboration between the fishing industry and ocean observing community by meeting with and

engaging industry (North Atlantic Seafood Forum) to provide advice on ocean observing system requirements to facilitate an industry led ocean observing network.

Task 6.3 Multipurpose integration of BOOS & HELCOM observing networks (task leader: DMI, partner: TalTech), Deliverables D6.2, D6.6, PM1 - PM48

At present, operational oceanography and the environmental health monitoring activities in the same sea area are not well coordinated, e.g., Baltic Operational Oceanographic System (BOOS) and Helsinki Commission (HELCOM) in the Baltic Sea. HELCOM assessments are produced with some delay and, generally, do not contain all available near-real time data, while operational products would benefit from timely delivery of ocean health data that is not agreed yet. This EuroSea task will integrate efforts from BOOS and HELCOM monitoring networks, resulting in a more fit for purpose operational oceanography system and enhanced environmental assessments in the Baltic Sea. This task will: 1) improve timeliness of ship data delivery according to operational oceanography requirements starting from individual institutes and promoted in HELCOM; 2) carry out quarterly interim reanalysis by assimilating both BOOS and HELCOM data for a demo period; 3) carry out a rapid environment assessment based on integrated products for the demo period; 4) produce annual eutrophication assessment reports by using the HELCOM assessment tool; 5) produce quarterly or monthly assessment reports on marine extreme events; 6) assess the benefits of how the integration efforts improve operational products and environment assessments. All products will be published on BOOS and HELCOM websites.

Task 6.4 System Operation (task leader: Xylem, partner: CSIC, MI), Deliverable D6.7, PM1 - PM48

Ocean monitoring technology allows for real time management. This task will showcase the implementation of a new application for marine sensors to measure and forecast "*Extreme Marine Events*" with practical training provided to set-up, operate, maintain and interpret the data products produced. This task will: 1) develop a solution to measure "*Extreme Marine Events"* at key sites in the NE Atlantic (Ireland) and W Mediterranean (Spain) through a setup including optimal sensor, location and measurement cycles for ocean observing; 2) work with end users from the aquaculture industry (e.g. Mowi and CTAQUA) to determine maintenance capabilities and equipment available with support provided by scientists; 3) design and implement a solution (e.g. drawings for total system, data flow determined, production and test); 4) support system deployment and train users; 5) facilitate deployment at key sites, train scientists and local site crew; 6) assimilate data into models, understand the algorithm output, develop how to add value to industry (e.g. aquaculture) operation based on the algorithm output, and present to end users. Maintenance of the in-situ sensors, data ingestion into the EuroSea ocean observing system, in the long term, will rest with the aquaculture partners with support from the scientists.

Deliverables

D6.1: Report on the connections between "Extreme Marine Events" and Biological EOVs, PM33. **D6.2:** Annual and quarterly assessments and description of the production system, PM36. **D6.3:** Method or Standard Operating Procedure on how to create "Extreme Marine Events" Hazard maps & forecasts Report, PM40. **D6.4:** Linking oceanographic products to fisheries advice, PM40. **D6.5:** Sustainability and Business Plan Report, PM48. **D6.6:** Assessment of the benefits of the BOOS-HELCOM integrated system and recommendations for transfer this to other sea areas, PM48. **D6.7:** Real-time data to central server with display to stakeholders, PM48.

WP No	**7**	**Lead beneficiary:**		**MOI, IO PAN**			
WP Title	Ocean climate indicators demonstrator						
Participant No	1	4	11	14	16	17	18	19
Short name of participant	GEOMAR	**MOI**	CMCC	SU	ECMWF	**IO PAN**	IfW	Euro-Argo Eric
PM per participant	22	15	12	13	12	5	8	1
Participant No	20	21	48	53	54	55		
Short name of participant	CNRS	IFREMER	IRD	UFPE	MUN	DAL		
PM per participant	16	9.8	1					
Start month	1			**End month**	48			

Objectives

This WP addresses innovative ways to assess the role of the oceans and seas in the Earth's climate through the development, evaluation – including uncertainties - and dissemination of ocean climate indicators and their value for key end-users in economy (e.g. blue economy), societal (e.g. policy) and environmental sectors (e.g. climate science), i.e. the three pillars of sustainable development. The key objectives are:

- To generate a feedback loop between EuroSea, climate and ocean services, the economy sector, and decision makers by co-examining ocean climate indicators, assessing their uncertainties and quantifying their economic value.
- Provide user-relevant products for ocean climate monitoring and deliver ocean forecasting indicators in support of improved ecosystem management, risk management and blue growth.
- Carry out AtlantOS (H2020) recommendations for observing system strategies, and demonstrate the improvements though ocean climate indicator developments with decreased uncertainty.

WP leader and co-leader: Karina von Schuckmann (MOI), Maciej Telszewski (IO PAN)

Description of work

Task 7.0 Coordination & Co-development (MOI, IO PAN), PM1 - PM48.

This task includes the coordination of the WP, interfaces between WP7 tasks and other EuroSea WPs. The work package leaders will ensure that the planned work is carried out according to plan and budget and that the deliverables are produced and milestones are attained on time. Additionally, the leaders will ensure the establishment of the link with EuroSea project coordination and that the decisions taken at steering level are implemented. This includes as well the management of risk registers and mitigation measures.

Task 7.1 Carbon audit of the European relevant deep convection regions (task leader: GEOMAR, IfW; partner: Euro-Argo Eric, CNRS, IFREMER, DAL, MUN, DAL, MOI), Deliverables D7.3, D7.5, PM1 - PM48

This task will evaluate the economic value of the ocean carbon sink in deep convection regions via operational carbon assessments using a combined observing, integration, and dissemination approach. The removal of anthropogenic carbon is crucial for effective and efficient climate mitigation and economic benefit, for example in the context of global stocktake as part of the COP21 Paris agreement. An initial estimate for the value of regional ocean carbon uptake (cost-benefit approach) is provided by the social cost of carbon (SCC), which measures the marginal impact of carbon emissions, i.e. the marginal damage resulting from an additional ton of carbon dioxide emitted or marginal damage avoided by reducing emissions by one ton. The cost-effectiveness approach (SCC in the context of the Paris Agreement) measures people's marginal willingness to pay to achieve a climate goal that may include an exogenously determined temperature goal. Lastly varying carbon uptake can be expressed in market-based carbon prices in the European emission-trading scheme (EU-ETS).

Uptake of ocean carbon takes place in specific oceanic regions where surface water is forced by vigorous air-sea interaction to sink to deep ocean layers, notably the western Subpolar North Atlantic and the Gulf of Lion in the Mediterranean Sea. The approach to be used is based on routine CMEMS mapping of Lagrangian and Eulerian data at different ocean depth layers and time steps. In addition, the temporal evolution of gas exchange processes (convection center) and carbon transport (boundary currents) are estimated, and their link/contribution to the regional carbon variability. By making use of the quantified carbon variability, economists estimate the value of the carbon variability using three approaches, i.e. cost-benefit approach, cost-effectiveness approach, market-based carbon prices. Sustained observing efforts in the context of regional observing systems (e.g. AtlantOS), satellite data, national campaigns (OVIDE, OSNAP, MOOSE) and initiatives (Canadian OFI LabSea2020) are augmented by deployments of a few critical components, such as DEEP Argo floats, by EuroSea. Data from the Deep-Argo floats combined with other data (e.g. other Argo floats and the Ovide program time series) will be used to monitor the uptake of carbon in the Irminger Sea and to determine whether the signal is exported away within the deep circulation. Mechanisms involved in the storage and propagation of the carbon signal will be investigated.

The ocean observing value chain for the carbon audit will be further assessed aiming to identify the critical components for the auditing, and whether or not the auditing can be operationalized (e.g. as CMEMS indicator; connected to the Ocean State Report). The results of the EuroSea carbon audit will be communicated in user/producer meetings and at a policy briefing to discuss co-designed and identify new users/market opportunities.

Collaborators: Ocean Frontiers Institute & DFO, Canada. The observational component will benefit from the G7 partner Canada investment of up to 5.6 million Cd$ in Argo floats for the Canadian Waters and the Labrador Sea as a whole.

Task 7.2 Demonstrate societal benefit of physical Ocean Monitoring and Forecasting Systems: Design of user driven products (task leader: CMCC, ECMWF; partner: MOI), Deliverables D7.4, PM1 - PM36.

This task will generate observable and user-relevant ocean climate and forecasting indicators with reliable uncertainty for the Atlantic Ocean and Mediterranean Sea. The aim is to demonstrate the end-to-end connection from climate and seasonal forecast products to a wide variety of stakeholders. The method is to implement EU Copernicus products (CMEMS, C3S) into a novel decision-making tool for policy and other stakeholder (e.g. aquaculture and fisheries). WP2 elaborates the best observing strategies for EOVs, and the data assimilation and forecasting systems in WP4 deliver a 4-dimensional view on EOVs over past, present and future. This task will use

records of EOVs from ocean observing systems, CMEMS, ESA-CCI and the output of seasonal forecast from C3S, to create user-driven calibrated ocean climate and forecasting indicators identified in consultation with stakeholders. The development of indicators and services will be based on three EOVs and indicators will cover global and regional aspects. Stakeholders will cover both relevant international bodies as well as regional conventions. Sectorial applications include ocean health, weather and climate, and industries see Table below).

Observable EOV	**Indicators/Sectorial application**			
	Marine Industry	Ocean Health	Climate	Weather
SSH (CMEMS, C3S: satellite & reanalyzes)	Ocean Circulation (Fisheries/Transport)		Ocean Circulation, Sea-level rise	European climate (Gulf Stream, Subpolar gyre)
T(z) (Observing systems, CMEMS: in situ & rénales)	Subsurface warming (Aquaculture/Fisheries)	Marine heat waves	Heat uptake	Subtropical storms, Tropical cyclones
SST (CMEMS, ESA-CCI: satellite & in situ)	Surface warming (Aquaculture/Fisheries)	Marine heat waves	Climate change, ENSO	Tropical cyclones, Mediterranean heat waves

Verification and calibration of seasonal forecast ocean indicators using EOVs. Indicators for the WP7 recommendation are obtained from WP2 (observations) and WP4 (model, forecast); the outputs are used to: a) Verify the forecasted indicator based on past performance; b) Identify the biases and skill; c) Conduct the quantile mapping for probabilistic calibration. The calibrated products will be verified in a second iteration in cross-validated mode, to avoid artificial skill estimations.

Collaborator: Copernicus Marine Service; Copernicus Climate Change Service

Task 7.3 Quality enhancement of tropical carbon fluxes through network optimization of the Tropical Atlantic Observing System (task leader: GEOMAR, SU; partner: Euro-Argo Eric, IRD, UERJ, UFPE), Deliverables D7.1, D7.2, D7.6, PM1 - PM48.

Task 7.3 will develop indicators for carbon flux across the air-sea interface and for ocean acidification based on an improved Atlantic observing system. Demonstrating improved quality of carbon measurements at a regional scale is important for the implementation of SDG 14.3.1. An improved network design would be of benefit for stakeholders (e.g. local fisheries) by providing access to near real-time environmental data. In this task, in situ biogeochemical data from autonomous platforms (e.g. BGC-Argo, core-Argo, moored instrumentation, and long-range ASVs) and shipboard data (GLODAP, SOCAT) will be used and analyzed together with complementary networks such as remote sensing, atmospheric reanalysis, empirical (neural network) and mechanistic modelling.

Tropical Atlantic Observing System (TAOS) optimization demonstration following an integrative multi-platform approach. Existing components of the TAOS will be upgraded for autonomous carbon observations (PIRATA 8N38W site) and the emerging BGC-Argo network will be further strengthened through EuroSea BGC-Argo float deployments in the region to improve spatio-temporal coverage of carbon measurements at the air-sea interface and at depth (pCO2, pH, POC). ASVs equipped with instrumentation for high-quality carbon measurements will be sent out on a multi-month pilot mission to integrate carbon measurements from different platforms. GEOMAR will provide a fully equipped Wave Glider for this mission and in cooperation with the US company Saildrone. A wind-powered ASV will join this mission to test how such a commercial ocean observing service can be optimally nested in a global ocean observing framework. The company aims to develop a global fleet of their drones in order to provide high resolution and multidisciplinary data as a service to end-users such as agencies, scientists and the private sector. Saildrone cooperates with NOAA enabling Saildrone to carry out high-quality carbon measurements from their vehicles. So far, this technology has been used primarily for process studies and EuroSea will explore the possibility together with Saildrone to implement this as a service nested in a global ocean observing framework. Data dissemination pathways to end-users will be developed in cooperation with WP4. Time-Series stations in the North (Cape Verde Ocean Observatory) and South Atlantic (Fernando de Noronha Observatory) will provide benchmark data for measurement validation.

Developing BGC-Argo data validation tool. A methodology to increase carbon data quality of the emerging BGC-Argo network will be developed, using TAOS as a demonstration environment. The current BGC-Argo data validation procedure, based on GLODAP data, will be extended by systematic crossovers with at the surface during the pilot study, thereby reducing uncertainties in CO_2 flux estimates and ocean acidification indicators.

Upscaling carbon fluxes over the tropical zone. This will rely on a synergistically combination of remote sensing of ocean color**,** the multi-platform approach deriving air-sea CO_2 flux, and the use of neural network techniques. Ocean color satellite-based bio-regionalization of the tropical Atlantic will be established. It will serve to delineate the various zones where relationships between surface (physical and biogeochemical) environmental constraints

(the predictor variables) and carbon surface fluxes (the predicted variables) will be empirically established through neutral network. These relationships will subsequently serve to upscale, from surface predictors including ocean color and other satellite or reanalysis surface products, carbon fluxes for the whole tropical domain.

Deliverables

D7.1: Report on demo mission and dissemination pathways of obtained data based on different observational platforms, PM28. **D7.2:** The data validation tool will apply GLODAP data at depth along with ASV surface data to enhance BGC-Argo pH data quality, PM32. **D7.3:** Identification of key drivers for the observed changes in carbon uptake at the convection sites, PM36. **D7.4:** Verification and calibration of seasonal forecast ocean indicators using ECVs/OCVs, PM36. **D7.5:** Report on estimation of economic benefit of regional ocean carbon uptake based on the three approaches (cost-benefit, cost-effectiveness, market-based carbon prices in the EU-ETS), PM40. **D7.6:** Quantification of improvements in carbon flux data for the tropical Atlantic based on the multi-platform and neural network approach, PM40.

WP No	**8**		**Lead beneficiary:**			**EuroGOOS, GEOMAR**	
WP Title	Communication: Engagement, Dissemination, Exploitation, and Legacy						
Participant No	1	2	6	15	22	23	24
Short name of participant	**GEOMAR**	**EuroGOOS**	MI	SOCIB	RBINS	SciencEthics	ISPRA
Person months per participant	13	18.5	15	15	10	12	2.9
Start month	1					**End month**	50

Objectives

The WP objectives have been defined to underpin: 1) the project's demos - towards their business exploitation, and 2) the project itself - towards sustaining the project's results, enabling/fostering science-policy and public-private partnership interfaces, and strengthening the European leadership in ocean observing.

- Deliver professional communications, stakeholder engagement and business exploitation support to the project and its demonstrators.
- Enhance collaborative, inclusive, and strategic stakeholder dialogue that moves beyond stakeholder consultation towards co-design.
- Enable exploitation of the project's results and products in business sector, sustainable strategic partnerships and governance, as well as strategic foresight.
- Provide tangible support and guidelines on intellectual property rights and business development along the Responsible Research and Innovation principles and best practice in knowledge and technology transfer.
- Support capacity building to empower strategic partnerships, support business development and communicate achievements effectively.
- Ensure the project's legacy is sustained with consolidated contributions to short, medium and long-term project's goals.

WP leader and co-leader: Dina Eparkhina (EuroGOOS), Anja Reitz (GEOMAR)

Description of work

This WP is dedicated to Communication, including four main tasks: Engagement, Dissemination, Exploitation, and Legacy. This work package will deliver critical support to the project and its demonstrators, assisting EuroSea in the delivery of viable and targeted outputs through stakeholder engagement and co-design. WP8 will showcase how EuroSea is improving the information provision to a range of users, working efficiently throughout the value chain of ocean information, from observations to data processing and modelling and to services. To achieve sustained legacy, WP8 will address the sustainability of the project's results and deliver an input into the ocean observation strategies within the G7, Belmont Forum and UN Ocean Decade.

Task 8.0 Coordination (task leader: GEOMAR, EuroGOOS; partner: MI, SOCIB, RBINS, SciencEthics, ISPRA), Deliverables D8.2, PM1 - PM50.

This task will coordinate the WP across its objectives and the four main tasks and will: 1) define the WP work plan in liaison with the other WP leaders and fellow task leaders in WP8; 2) determine actionable operational links with the other project's WPs and the WP8 tasks; 3) organize regular web calls, at least quarterly, to follow the progress; 4) report on the WP work at the project meetings; 5) attend relevant EuroSea and other meetings and workshops, 6) conduct capacity building on stakeholder co-design, business development and IPR, effective communication, societal relevance, and behavior change, through a series of workshops for internal and external capacity development.

Task 8.1 Engagement (task leader: EuroGOOS, GEOMAR; partner: SciencEthics, MI, RBINS, ISPRA, SOCIB), Deliverables D8.3, D8.5, D8.7, D8.11, PM1 - PM50

This task will help to build/foster interfaces and partnerships with the project's stakeholders and help achieve the demos' exploitation targets. This will be done by identifying the messages (outputs, results, concepts) to be communicated to the project's stakeholders and the demonstration project's targets. We will make a consolidated and concrete list of the project stakeholders and demos' targets. While the targets have been broadly identified within the project's objectives and the demos' tasks, this task will analyses the stakeholder personas to inform targeted dissemination and engagement strategies.

The task will assist the development of demo activities on system design and governance using the RRI guidelines and stakeholder engagement mechanisms established through the previous EU initiatives, including the EU H2020 action Marina. This task will also enabling and fostering dialogue towards co-design, sustained operation and legacy by designing public-private partnership and science-policy interfaces needed to sustainably engage with the project's stakeholders and demos' targets/users. To aid this process, workshops will be organized focusing on: 1) public-private interfaces, and 2) science-policy interfaces. Engagement will be considered with established platforms like the Ocean and Climate Platform. This task will organize an event at the European Parliament to showcase the EuroSea demos' implementation in business development through stakeholder co-design, RRI and in coherence with relevant national and international policies and strategies, and will engage with global science and science-policy communities through showcases at international events.

This task will develop a public engagement resource portfolio on the importance of ocean observing for environmental policies and Blue Economy, along the Ocean Literacy principles. It will also be influencing the next generation of professionals in the ocean observing value chain through targeted engagement activities and taking into account the recommendations of the European Marine Board Future Science Brief 2 on marine graduate training (2018).

Task 8.2 Dissemination (task leaders: SOCIB, RBINS; partner: EuroGOOS, GEOMAR), Deliverables D8.1, PM1 - PM50.

This task will deliver professional outreach activities to profile the project and its demos towards policy makers, industry and science users, as well as the general public through media dissemination. The subtasks will include professional outreach activities to profile the project and its demos towards policy makers, industry and science users, as well as the general public through media dissemination. The tasks will: 1) design and implement a communication plan that includes communication practices targeted at different audiences, styles (content, mood, languages), communication channels (incl. working with media), crisis plan, offline/online communication strategies, action plan and evaluation; 2) develop and maintain the EuroSea website (including subcontracting a webmaster); web news (or the relevant info needed to write web news) to be provided by all partners (EuroGOOS); 3) set up and maintain an EuroSea Twitter account (EuroGOOS); 4) produce an interactive EuroSea exhibition oriented to society, policy and industry, in liaison with the project's partners (SOCIB); 5) create a public awareness video (SOCIB); 6) organize a series of thematic webinars on the project and findings to help generate momentum around them, collect stakeholder feedback, and foster cooperation for the results' sustainability (GEOMAR).

Task 8.3 Exploitation (task leader: MI; partner: ISPRA, SciencEhics), Deliverables D8.4, D8.6, D8.8, PM1 - PM50.

Exploitation strategy: Task 8.3 will advance the exploitation of both the project and the demonstrations' results, delivering guidance and support to the demonstration WP partners on co-design issues. The task will identify the key outputs of the project, with a particular emphasis on the demonstration work packages, with the aim of developing a set of strategies for their exploitation (commercial, scientific and otherwise) and sustainability.

This will involve, firstly, supporting the production of individual exploitation plans within each of the demonstrations (e.g. by supplying common tools, methodologies and templates), and building on them to extend, consolidate and further develop them in a coherent and connected manner. This will help to inform an exploitation strategy that will outline a pathway to market for each of the demonstration products/services. Specialist consultancy services will be required to develop a draft plan for the management of Intellectual Property Rights (IPR) and related processes and procedures. This will involve providing IPR support and guidelines to the demonstration WP partners, and the establishment of monitoring procedures to recognize and capture IP, as the technological maturity of the outputs increases.

Business plan: This sub-task will involve the development of a business plan for the commercially exploitable products and services co-developed in WP5,6,7, including a detailed market analysis as a key component. This will involve determining the market size and potential for the demonstrations and the development of an overall strategy for market penetration. This covers issues such as price, positioning and promotion (which, along with 'product', make up the 4 'Ps' of marketing) as well as strategic partnerships and possible organizational structures supporting commercial activity (e.g. spin-off companies).

Value of ocean observations: In complement to the market analysis, a study on the economic value of ocean observing activities will be carried out. Value chains in the industrial sectors supported by ocean observations will

be examined and the marginal benefits accrued through the improved decision-making, foresight and situational awareness will be estimated. As part of this study, the economic value of the individual demonstrations and their potential economic impact will also be analyzed.

Task 8.4 Sustaining legacy (task leader: SciencEthics; partner: ISPRA, SOCIB, RBINS, MI, EuroGOOS, GEOMAR), Deliverables D8.9, D8.10, D8.12, PM1 - PM50.

This task will help distil and sustain the project's legacy, deliver advice on RRI guiding principles, best practice in knowledge and technology transfer, and ensure the project's outcomes and legacy inform relevant political agendas. All best practices will be sustained beyond the project lifetime in an open-access online repository. This task will:

- Deliver best practice in knowledge and technological transfer through public-private and science-policy interfaces, to inform the project and its demos and ensure the project's own best practices are analyzed and sustained in an open access repository.
- Support the development of demos and sustained system design and governance and engage closely with EuroSea partners on the RRI and ethical principles, ecosystem and human health approach and governance and policy instruments.
- Deliver a set of fit-for-purpose guidelines to anticipate the commercialization of services and products delivered by the demos and prepare targeted case studies on the implementation of the RRI principles.
- Deliver project recommendations and a legacy report addressing short, medium and long-term project's goals that will inform bodies like the G7's working group, UN Ocean Decade, GOOS, etc.
- Support the organization of the EuroSea legacy conference led by WP9 Coordination.

Deliverables

D8.1: Communication Plan, PM4. **D8.2:** Updated Dissemination and Exploitation plan, PM12. **D8.3:** Lessons learnt on science-policy interfaces in European ocean observing, PM24. **D8.4:** Project exploitation strategy, PM 24. **D8.5:** Lessons learnt from the EuroSea public engagement activities on the importance of ocean observing for environmental policies and Blue Economy along the Ocean Literacy principles, PM32. **D8.6:** Report on economic value of ocean observations highlighting the potential economic impact of the demonstrations and analyses the value of the ocean observing system, PM36. **D8.7:** Lessons learnt on public-private interfaces in European ocean observing, PM40. **D8.8:** Business plan that will highlight the value added of an integrated ocean observing system, PM40. **D8.9:** Recommendations on the implementation of RRI in ocean observing system design and innovation, PM45. **D8.10:** Best practice in the visualization of the ocean's societal relevance and economic role, PM45. **D8.11:** Recommendations on engaging with the next generation, PM49. **D8.10:** EuroSea Legacy Report, PM49.

WP No	**9**	**Lead beneficiary:**			**GEOMAR**
WP Title	Project Coordination, Management and strategic ocean observing alliance				
Participant No	1	21	33		
Short name of participant	**GEOMAR**	IFREMER	HCMR		
Person months per participant	50.5				
Start month	1			**End month**	50

Objectives

- Provide top level management of the project to ensure aims of the project are efficiently and effectively met, on time and with the resources budgeted and that knowledge and innovation are properly managed
- Provide effective reporting and communication within the project, between partners and stakeholders and between the consortium and the European Commission (EC)
- Provide support for and activities aimed at project internal integration
- Provide connections and interfaces with other projects funded under this topic

WP leader: Toste Tanhua (GEOMAR)

Description of work

Task 9.1 Project coordination and management (GEOMAR), Deliverables D9.1, D9.2, D9.4, PM1 - PM50.

Management of the project: The project coordination unit (PCU) at GEOMAR will be in charge of managing the project using effective management procedures based on the project cycle management formal methodology. This task will provide: 1) a **consortium agreement** that will regulate the consortium, rules for participation, and ownership and access to key knowledge (IPR, foreground, etc.); 2) provision of administrative/financial/legal support to all partners involved during the implementation of the project; 3) organization of the Kick-off and three General Assembly Meetings from which the final one will have a specific focus on the EuroSea legacy, 4) management of internal and external project advisory boards that will meet at least once a year during the General

Assembly meeting (prior to the GA meetings these boards will receive an action progress report; 5) preparation of Periodic Project Reports including financial reporting, and the Final Report to the European Commission.
The project coordinating unit (PCU) at GEOMAR will be closely linked to WP8 to ensure direct information flow to foster effective communication and promotion of the project and its demonstration activities (**WP5,6,7**). Furthermore, WP9 will be extensively involved in the communication of project results through provision of reports, communication with the EC, engagement related projects and stakeholders, teamed-up with T9.2 and **WP8**.
Regular and comprehensive communication with the EC: The conduit for this will be the PCU. This task will ensure the appropriate follow-up of project obligations from the Grant Agreement (scientific, reporting of science results and finances, communication, and management). The PCU will ensure that at least one EC representative is invited to the project meetings. If there are any major problems within the project that cannot be solved through the appropriate management structure, the PCU will liaise with the EC in order to seek advice and a solution.
Coordination of internal communication within the project: The PCU will ensure optimal internal communication through a dedicated intranet and regular teleconference calls as well as through the agreed formal face-to-face meetings. The intranet will be set up to include documents and tools that will aid the management and reporting of the project. Additionally, an internal newsletter and an internal website will be set up for the exchange of information within the partnership, and to provide templates, guidelines and clarifications for administrative and scientific staff. The main communication tools in the project are the intranet, remote communication, and meetings.
Technical support to the project committees and panels: The PCU will provide administrative support to the committees and panels (see Section 3.2) of the organizational structure of the project. This will include administrative tasks involved in the preparation, executing of and post-processing of major project meetings of the committees and panels, i.e. agendas, invitations, location of meeting places, organization of rooms and equipment, preparation, distribution and archiving of materials, minutes and action lists.

Task 9.2 Interfaces to other projects under this topic (task leader: GEOMAR; partners: HCMR, IFREMER), Deliverables D9.3, PM1 -PM50.

Cluster with relevant projects: This task will cluster with other projects financed under this topic and with other relevant project funded by Horizon 2020 or by the partners of the Galway and Belem agreements. This will be done on a strategic level and, on an operational level; the task will draw from the relevant expertise in EuroSea WPs to be able to interact and coordinate at the appropriate level, with the aim of avoiding duplication of efforts and to optimize the knowledge generated in the projects. Close links of the partners in WP9 and Atlantic Ocean Research Alliance (AORA) and the Belem partners do exist and will be intensified. The task will assure that requirements and needs of the ocean observing and forecasting system are properly communicated to other relevant projects working on, for instance the blue cloud services or innovative technologies for observations. This will be a continuous task in the project, and it will produce a strategy report on technical innovation and data management needs for a sustained ocean observing system.

Deliverables

D9.1: Action Progress report #1, PM14. **D9.2:** Action Progress report #2, PM30. **D9.3:** A strategic report for the technical innovation and data management needs, PM44. **D9.4**: Action progress report #3, PM48.

Table 3.1c: *List of major deliverables*

DEL (no)	Deliverable name	WP no	Lead Partner	Type	Dissemination level	Delivery date (month)
D8.1	Communication Plan	8	RBINS	R	PU	4
D3.1	Data Management plan	3	IFREMER	R	PU	6
D1.1	Report on policies in foresight in OO	1	EMB	R	PU	9
D1.2	Map of BioEco Observing networks/capability	1	IOC-UNESCO	R	PU	12
D2.1	Design of the OSSEs with multi-platform in situ data and impact on fine-scale structures	2	CSIC	R	PU	12
D3.2	Observing Networks initial Assessment	3	GEOMAR	R	PU	12
D8.2	Updated Dissemination and Exploitation plan	8	EuroGOOS	R	PU	12
D3.3	New tide gauge data flow strategy	3	EPPE	R	PU	14
D9.1	Action Progress Report #1	9	GEOMAR	R	PU	14
D3.4	HF-Radar Governance	3	AZTI	R	PU	18
D3.5	ASV-Network structure and roadmap	3	PLOCAN	R	PU	18

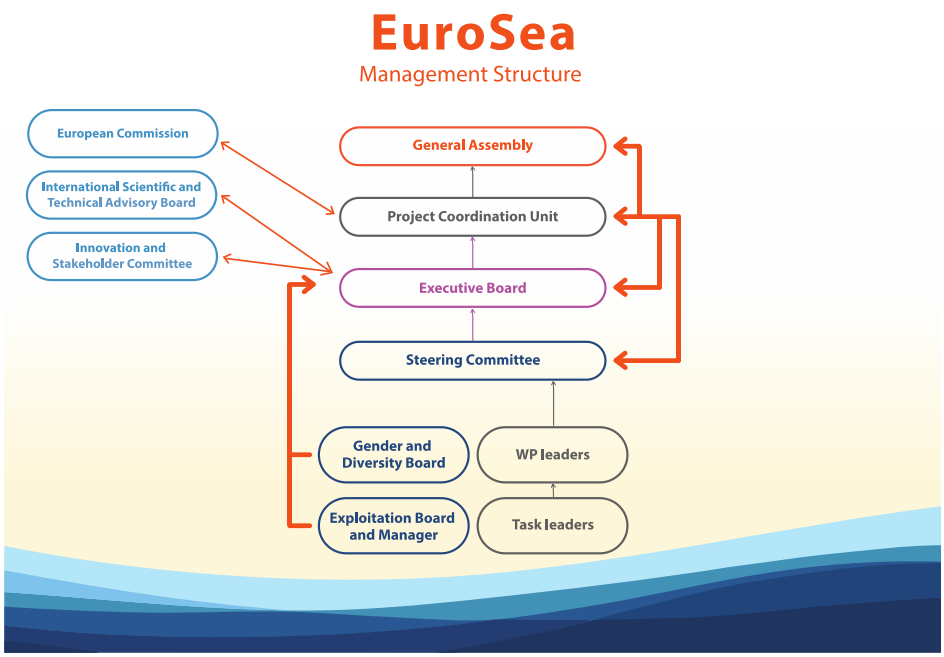
D5.1	Prototype sea level planning and scenario visualization tool	5	ARUP	DEM	PU	18
D1.3	Report of OBPS Community meeting	1	IEEE	R	PU	20
D2.2	Analysis of the physical and BGC design experiments	2	MOI	R	PU	24
D3.6	Sensor implementation on Eulerian Obs.	3	SU	R	PU	24
D4.1	Design of experiments (global/IBI)	4	MOI	R	PU	24
D4.2	Design of the glider assimilation experiments	4	CMCC	R	PU	24
D4.3	Derive observable ocean climate indicators from seasonal forecast	4	ECMWF	DEM	PU	24
D5.2	Mediterranean sea-level reconstruction spanning 1950-2017	5	UKRI	R	PU	24
D5.3	CMEMS downscaled circulation operational forecast system	5	CMCC	DEM	PU	24
D5.4	CMEMS downscaled wave operational forecast system	5	UPC	DEM	PU	24
D5.5	Final version of the software running operationally for the demonstration	5	Nologin	OTHER	PU	24
D5.6	Documentation associated to the capacity building	5	UKRI	R	PU	24
D8.3	Lessons learnt on science-policy interfaces	8	EuroGOOS	R	PU	24
D8.4	Project exploitation strategy	8	MI	R	PU	24
D1.4	Report on European BioEco networks	1	IOC-UNESCO	R	PU	27
D1.5	Marine Plastics EOV and common sampling protocol	1	IO PAN	R	PU	27
D7.1	Report on demo mission and dissemination pathways of obtained data	7	GEOMAR	R	PU	28
D1.6	Maps and metrics on observing systems and metadata	1	IOC-UNESCO	R	PU	30
D2.3	Analysis of the OSSEs with multi-platform in situ data and impact on fine-scale structures	2	CSIC	R	PU	30
D3.7	WP3 network harmonization recommendations	3	IFREMER	R	PU	30
D4.4	Temperature and Salinity QC	4	UiB	R	PU	30
D9.2	Action Progress Report #2	9	GEOMAR	R	PU	30
D7.2	Development of BGC-Argo data quality validation based on an integrative multi-platform approach	7	GEOMAR	R	PU	32
D8.5	Lessons learnt from the EuroSea public engagement activities	8	SOCIB	R	PU	32
D6.1	Connections between "Extreme Marine Events" and Biological EOVs Report	6	MI	R	PU	33
D5.7	Automated tide gauge data quality control software and report	5	UKRI	DEM	PU	34
D5.8	Mediterranean trend and acceleration sea-level esti-mates (reduced uncertainty, recalculation toolbox)	5	UKRI	R	PU	34
D2.4	Development of targeted indicators and their uncertainties for demonstrators and Forecasts	2	ENS	R	PU	36
D3.8	EuroSea Strategic vision	3	SOCIB	R	PU	36
D3.9	Glider network, European coordination	3	CNRS	R	PU	36
D3.10	Gliders metadata	3	WMO	R	PU	36
D3.11	Eulerian Best Practices	3	SU	R	PU	36
D3.12	Eulerian metadata catalogue	3	SU	R	PU	36
D3.13	EuroSea data handbook	3	IFREMER	R	PU	36

D4.5	Synthesis of satellite validation results	4	CLS	R	PU	36
D4.6	Skill assessment of ECV/EOV from seasonal forecast	4	ECMWF	R	PU	36
D4.7	SOCAT Quality Control (QC) procedures	4	UiB	R	PU	36
D5.9	Operational monitoring systems available at the three sites	5	UKRI	DEM	PU	36
D6.2	Demonstration of annual/quarterly assessments and description of the production system	6	TalTech	DEC	PU	36
D7.3	Estimate of magnitude and drivers of regional carbon variability for both regions	7	CNRS	R	PU	36
D7.4	Skills of the user-relevant ocean indicators	7	ECMWF	R	PU	36
D8.6	Report on economic value of ocean observations	8	MI	R	PU	36
D3.14	HF-Radar Tools	3	AZTI	R	PU	38
D1.7	Report on the use of legal frameworks for OOSS	1	EMB	R	PU	40
D6.3	"Best" Practice on creating "Extreme Marine Events" Hazard maps & forecasts Report	6	MI	R	PU	40
D6.4	Linking oceanographic products to fisheries advice	6	CSIC	R	PU	40
D7.5	Economic benefit of regional ocean carbon uptake	7	IfW	R	PU	40
D7.6	Integration of in situ and satellite multi-platform data (estimation of carbon flux for trop. Atlantic)	7	SU	R	PU	40
D8.7	Lessons learnt on public-private interfaces	8	ISPRA	R	PU	40
D8.8	Business plan for EuroSea demonstrators	8	MI	R	PU	40
D3.15	Tide gauge metadata catalogue	3	MI	R	PU	42
D4.8	Assess impact of observations	4	EPPE	R	PU	42
D4.9	Intercomparison of glider assimilation in the different analysis and forecasting systems	4	SOCIB	R	PU	42
D4.10	Results of the BGC data assimilation	4	OGS	R	PU	42
D4.11	Evaluation of Extreme Forecast Indices (WP5+6)	4	UNIBO	R	PU	42
D3.16	Euro-Argo updated strategy	3	Euro-Argo Eric	R	PU	44
D3.17	EuroSea data integration	3	IFREMER	R	PU	44
D3.18	Observing Networks final Assessment	3	HCMR	R	PU	44
D3.19	Omics community protocols	3	SZN	R	PU	44
D9.3	Ocean Observing Needs	9	GEOMAR	R	PU	44
D5.10	Final report describing the demonstration and the user feedback at European sites	5	EPPE	R	PU	45
D5.11	Scientific model validation report during the demonstration period	5	EPPE	R	PU	45
D8.9	EuroSea recommendations on RRI in OO	8	SciencEthics	R	PU	45
D8.10	Best practice in the visualization of the ocean’s societal relevance and economic role	8	SOCIB	R	PU	45
D1.8	Final Report of EOOS Implementation Plan	1	EuroGOOS	R	PU	48
D4.12	GLODAP Quality Control (QC) procedures	4	UiB	R	PU	48
D6.5	Sustainability and Business Plan Report	6	MI	R	CO	48
D6.6	Assessment of the benefits of the BOOS-HELCOM integrated system and recommendations for transfer this to other sea areas	6	TalTech	R	PU	48
D6.7	Real-time data to central server with display to stakeholders	6	Xylem	DEC	PU	48
D9.4	Action Progress Report #3	9	GEOMAR	R	PU	48

D8.11	Recommendations on engaging with the next generation of stakeholders	8	RBINS	R	PU	49
D8.12	EuroSea Legacy Report	8	EuroGOOS	R	PU	49

3.2 Management structure, milestones and procedures

3.2.1. Description of the organizational structure and the decision-making



The organizational (Figure 6) and governance structure of EuroSea is designed to meet the needs of a large scale and international project. Over-complexity has been consciously avoided; instead, the structure will enable appropriate designation of responsibilities and optimal flow of information within and across work packages, and between participants, advisors, invited stakeholders and the European Commission.

Figure 6. *Overall Management Structure for EuroSea*

The Coordinator of the EuroSea is Dr. Toste Tanhua (GEOMAR). He has a long standing expertize in ocean observing and is currently co-chair of GOOS and partner in AtlantOS. He is responsible for the overall coordination of the project and chairs the General Assembly, Executive Board, and Steering Committee Meetings. The Scientific and Technical Manager (Dr. Anja Reitz/GEOMAR), responsible for the day-to-day implementation of the project, support him. Dr. Anja Reitz is currently managing the H2020 large-scale RIA AtlantOS (633211).

The Coordinator and the Scientific and Technical Manager will liaise with the European Commission on behalf of the consortium, with the Coordinator as the primary contact point.

Dedicated roles are foreseen for: 1) decision-making bodies; 2) executive bodies; 3) advisory bodies, and 4) management bodies.

Decision-making bodies

The General Assembly (GA) is the ultimate decision-making body of the consortium. The GA will be called to validate key decisions or orientations for the action as a whole introduced by the Executive Board (EB). The GA is comprised of one representative of each consortium participant and is chaired by the Coordinator. Over the lifetime of EuroSea, there will be four formal GA meetings, which will be combined with the annual project meetings.

Executive bodies

The Executive board (EB) is the supervisory body for the execution of the action, and will monitor and analyses the actions progress and propose actions/decisions to the GA if required for the implementation of the work plan and in accordance to the Grant and Consortium Agreements. The EB is comprised of the Coordinator and up to five members of the Steering Committee (SC). The EB will be gender-balanced. The five SC members will be appointed during the project's kick-off meeting subsequent to prior online-suggestions.

Advisory Bodies

EuroSea will have internal and external advisory bodies. The internal bodies are comprised of members of the consortium and the external boards by external experts and/or stakeholders and members of the consortium (in case of the Innovation and Stakeholder Committee).

The Steering Committee (SC) makes propositions to the EB on the project's work plan, innovation issues or any matter related to the success of the project. The SC is comprised of the project coordination, the work package leaders and co-leaders, and a delegate of the Gender and Diversity board (GDB). The SC is gender-balanced.

The Gender and Diversity Board (GDB) raises gender, early career, and other diversity awareness within the consortium, currently the WP lead distribution is gender balanced. The Board will be chaired by Michele Barbier (she is an expert for responsible research and innovation) and will comprise 3 additional members that will be appointed during the project's kick-off meeting subsequent to prior online-suggestions. The GDB will develop a Gender and Diversity Action plan and will give advice to the SC and EB on the implementation of this action plan.

The Innovation and Stakeholder Committee (ISC) will monitor the project's innovation and exploitation activities to ensure that the potential of EuroSea activities is maximized. The ISC will respond to current technological and market trends, risks and opportunities. It will be comprised of one representative per demonstration activity, the task leader of task 8.3 *Exploitation*, at least one external stakeholder per demonstration activity, a representative of JPI Oceans and POGO, as key partners for innovation in Europe.

The International Scientific and Technical Advisory Board (ISTAB) will ensure scientific and technical evaluation of the action. The ISTAB is comprised of selected leading international experts and/or end users of EuroSea products that will be appointed during the project's kick-off meeting subsequent to prior online-suggestions. ISTAB members are not directly involved in project tasks but will review the project and advise the Coordinator and EB on overall strategy, especially at key milestone stages. They will meet annually with the EB, or more frequently if needed. They will advise on the appropriateness of the project planning to deliver key objectives, emerging issues that may need to be reflected in a project change, connection to stakeholders, and promotion of project outcomes at European and international and level. The status of the ISTAB is restricted to advisory only; any suggested change to the project must be agreed by the consortium and approved by the Commission.

An Exploitation Board and an exploitation manager will be appointed in order to ensure that the EuroSea development partners are focused on the market exploitation of their results. The Exploitation manager will report to the Executive Board. The Exploitation Manager will be provided by MI and further members will be technology transfer experts from EuroSea partners and representatives of the SMEs and companies within EuroSea (e.g. ARUP, Xylem, and Nologin). These additional members will be appointed during the Kick-off meeting.

Management bodies

The Project Coordination Unit (PCU) located at GEOMAR is responsible for the management of EuroSea. The PCU team includes the Coordinator, the scientific and technical manager and a financial assistant. The scientific and technical manager will be in charge of: 1) the day-to-day management of the action; 2) monitoring of planning and progress of the action; 3) proposals for corrective and preventive actions; 4) facilitating the communication within the consortium; 5) coordinating the reporting for the European Commission; 6) setting up of project meetings and reviews; 7) making sure that knowledge and innovation-related issues are made available and shared with the partners. The financial assistant is in charge of monitoring of the finances, supporting the partners in the implementation of the financial rules of Horizon 2020 and requirements deriving from the Grant and the Consortium Agreement, supporting the partners in preparing their interim financial payment requests, in dealing with the formalities of the financial reports and of the certificate of financial statements.

Two Work Package co-Leaders have been appointed per work package to ensure coordination and management of the work packages. They play a key role in the scientific management at the work package level, to ensure that the planned work at WP level is carried out according to plan. They are also responsible for budget and that the deliverables are produced and milestones are attained on time, to establish the link with EuroSea project coordination, and that the decisions taken at executive level are implemented at WP level. They will coordinate cooperation and exchanges with the partners across the EuroSea working fields. The work package leadership is gender-balanced.

One to two Task Leaders have been appointed for coordinating the efforts of the several partners involved in the task. The presence of the Task Leaders will ease and support the role of the Work Package Leaders, particularly for those tasks that involve several partners or cover complex topics and bear the risk of fragmentation. The task leadership is gender balanced.

In order to facilitate the management and to chart the progress of the project, milestones have been selected (Table 3.2a). To ensure appropriate co-design and cross cutting activities (meeting/workshops and cooperation activities) on the task-progress level, a number of internal milestones has been identified to enable work package and task leaders to foster and trace appropriate progress on that level. The list of internal milestones is available in annex 1.

Table 3.2a: *List of milestones*

Milestone No	Milestone name	Partner in charge	Related WP(s)	Due date (month)	Means of verification
MS1	Design of the OSSEs with global ocean monitoring systems	MOI	2, 4	6	Design developed and reported

MS2	Design of operational implementation of forecasting system in the Mediterranean Sea	UNIBO	4	6	Design developed and reported
MS3	Specification of user-needs and expectations Documented	CSIC	6, 8	9	Documented on the website
MS4	Public awareness video	SOCIB	8	10	Video online
MS5	Mapping plan for marine plastic contaminants	IO PAN	1	12	Agreed plan is written
MS6	Definition of EOVs in connection with demonstrators and Forecasts	ENS	2, 4, 5, 6, 7	12	Agreement on the definition achieved
MS7	Pilot global indices of SST/SLA/OHC calculated	ECMWF	4, 7	12	Data exchanged with WP7
MS8	Agreed products and planned services Documented	CSIC	6	18	Documented on the website
MS9	Deployment of BGC-Argo and PIRATA CO_2 sensor in trop. Atlantic	Euro-Argo-Eric	7	18	Notification instruments deployed
MS10	Requirements of EOVs and platforms for sustaining indicators for WP4-7	ENS	2, 4, 5, 6, 7	24	Agreement on the requirements for indicators
MS11	User driven indicators defined and selected EOV/ECV from ensemble of seasonal forecasts verified	ECMWF	4, 7, 2	24	Data exchanged and selected graphics shared with project partners
MS12	Work plan on the use of in-situ for satellite validation	CLS	4	24	Work plan established and written
MS13	Development of Temperature and Salinity QC procedures	GEOMAR	4	24	Procedures developed and documented
MS14	Prototype low-maintenance multi-parametric monitoring at 2 sites	UKRI	5	24	Prototype established and procedure documented
MS15	Linux based PC system with operational system ready to be implemented in non-European site	UPC	5	24	PC system established and running at demo sites
MS16	System for NRT data collection from cooperation of HELCOM and BOOS is developed	TalTech	6	24	Documented in BOOS & HELCOM annual meeting reports - available online
MS17	Deployment of instrumentation and cruises in MedSea & SPNA	GEOMAR,	3, 7	24	Notification instruments deployed
MS18	Accomplished ASV mission in TAOS environment	GEOMAR	7	24	Notification of accomplished mission, short technical summary
MS19	First version of the software, to be evaluated by users	Nologin	5	26	Documentation of user feedback
MS20	Itinerant exhibition	SOCIB	8	30	Exhibition installed
MS21	Validation of forecasting with glider data in the Mediterranean Sea	SOCIB	4	32	Validation conducted and reported
MS22	Prototype available for validation	Xylem	6	33	Demonstrator, pilot, prototype, plan designs
MS23	Policy-led and industry-lead stakeholder demonstration of prototypes	ARUP	5	36	Demonstration of prototypes
MS24	Installation of documentation, including calibration sheets	UKRI	5	36	Documentation of installation
MS25	"Extreme Marine Events" Hazard maps & forecasts - Website	MI	6, 8	36	Hazard maps & forecasts available online
MS26	Report on marine plastic contaminant monitoring	IO PAN	1	39	Report is written

MS27	Implementation of results into the CMEMS Ocean State Report	MOI	7	40	Results implemented in CMEMS
MS28	Report card from capacity building trainings	EuroGOOS	8	40	Report card
MS29	End-user satisfaction ratings Reported	MI	6, 8	45	Report with end-user satisfaction ratings
MS30	Ocean integration demo	CSIC	3	46	Report
MS31	Training webinars	GEOMAR	8	47	Several training webinars conducted

3.2.1 Appropriateness of the organizational structure and decision-making mechanisms

EuroSea has an organizational and decision-making structure that is well defined and provide for flexibility in the management and implementation of the various activities at different levels.

- The General Assembly ensures that all partners involved in the project can have a voice in the decision-making processes of EuroSea and is thus yielding transparency.
- The Executive Board plays a strategic role in the consortium as it collects input on specific issues from the advisory bodies and prepares the ground for decisions to be taken by the GA.
- The Steering Committee ensures that necessary proposition on the projects' work plan and innovation issue are communicated to the EB.
- The Gender and Diversity Board will promote and monitor gender, early career and other diversity issues such as regional and cultural appropriateness.
- The Innovation and Stakeholder Committee plays a strategic role in ensuring and maximizing EuroSeas' innovation and exploitation potential.
- The International Scientific and Technical Advisory Board will monitor the scientific and technical development and propose corrective actions if needed.
- The Work Package co-leaders are responsible for the scientific management at the work package level ensuring that the planned work is carried out according to the work plan.
- The Task Leaders are responsible of the scientific management on task level supporting the work of the work package leaders.
- The Project Coordination Unit ensures high quality and coherence in the implementation of EuroSea as well as prompt risk, quality, and conflict management. The target of the PCU is to reach maximum transparency for all involved parties to enhance project synergies.

Project Decision-making, Conflict Resolution and Reporting: In principle, the EB should arrive at decisions unanimously. If consensus decisions are not feasible or possible, a vote will be taken after the relevant issues have been comprehensively debated. All input to this decision process will be made through explicit, clear and comprehensive presentation of reasons and of the expected impact on project timings and objectives. All members will have one vote. The only exception to this rule is in the case of a hung vote when the Project Coordinator can cast an additional deciding vote. All decisions will be made expediently. Where approval is needed from the EC Project Officer, the decision will only be affective after written approval by the project officer has been received. Decision-making processes and conflict resolution mechanisms will be specified in the Consortium Agreement and signed off by all Participants. Regarding reporting, at specified dates every 6 months, each task leader will submit a progress report to their WP Leader. WP leaders will report every 6 months to the PCU on the progress made on the different tasks and deliverables. Deviations of the plan should be mentioned immediately to WP leaders and the PCU. In case the coordinator identifies a deliverable or a milestone as not delivered either in time or in a not acceptable/appropriate form, he will contact the WP leader(s) and requests their assessment within two weeks. The Project Coordinator will contact the EC if any deviation could jeopardize the project deliverables. Report templates will be provided for all interim, 6-monthly, and Annual and Final reports. These reports will clearly show progress against deliverables for that reporting period, milestones reached, plan of work for the next period, information about exchanges with other participants and any relevant engagement with stakeholders. All project participants will be bound by the project Confidentiality Agreement. The Coordinator and Project Manager will assemble the Annual and Final reports for the EC.

3.2.2 Innovation management

Innovation management will be covered in **WP5,6,7,8** to ensure a high level of industrial collaboration in the project, sound innovation management practices, and appropriate identification and management of exploitable results to increase the impact of EuroSea. The exploitation manager (MI), that will be a member of the Exploitation Board,

will lead it**.** The exploitation board will encompass technology transfer experts from EuroSea partners and representatives of the private sector EuroSea partners to ensure a strong focus on innovation, and to reinforce partnerships between research and industry organisations. Furthermore, an expert on business development and IPR that will be subcontracted will provide periodic advice. Innovation management will primarily focus on outcomes from WPs 3 and 5-7 with expectations for new or improved products, services or processes in: 1) coastal resilience and operational services e.g. Operational Services for Ports and Cities; 2) ocean health e.g. Extreme Marine Events alert system to aquacultures; 3) ocean climate indicators e.g. carbon audit to evaluate the economic value of the ocean carbon sink. The participation of large and SME industrial participants ensures that the market and technical problems will be well understood. Creativity will be encouraged across the project, and participants will respond to any internal or external opportunities for innovation. This Board is advising

The innovation management processes will follow guidance from the European IPR Helpdesk, in particular 'Managing Impact and Innovation in H2020 Projects'[10]. Through periodically subcontracting an expert on business development and IPR, we will ensure that all project participants understand the innovation management procedures and related exploitation strategy and plan, signed off in the Consortium Agreement. This expert will provide capacity building training. An exploitation roadmap will be developed WP8 to ensure that commercial and non-commercial results will increase the medium and long-term impact of the project and maximise opportunities for future exploitation. (Please see section 2.2 for description of IPR and exploitation measures).

3.2.3 Critical risks and mitigation actions (table 3.2b)

EuroSea brings together a highly experienced team with an excellent track record in project leadership, management, and collaboration in national, EU and international projects. Many consortium members have worked together previously; these solid working relationships and sound management practices reduce the likelihood of critical risks. The risk of one participant not collaborating is very low; nevertheless, the organizations in the consortium can propose experienced alternatives. There will be a routine analysis of risks as the project proceeds, and risk management will be focused on anticipating, identifying, preventing and controlling potential problems that could occur. Three main strategies will be followed to cope with risks: 1) avoidance strategies, to reduce the likelihood of the risk; 2) minimization strategies, to reduce the impact of the risk; 3) contingency planning, to select the best mitigation strategy. Potential risks will be flagged during the project through reporting from WP Leaders or participants. Critical risks will be reported immediately to the Project Coordinator, who will work together with the WP Leader to decide the best way to solve the problem; a conference call or meeting with the management board will be convened if necessary. Mitigation measures for critical risks (Table 3.2b) are based on the long track record of partners, particularly their practical experience in similar projects.

Table 3.2b: *Critical risks and mitigation actions for EuroSea*

Description of risk	WPs	Proposed risk-mitigation measures
Developments and innovations from EuroSea are not in line, or transmitted, to the broader European and Global Ocean Observing Objectives. **Low likelihood**	1, 8, all	Employ dedicated staff across EOOS and GOOS to enhance information to global ocean observing initiatives and relevant European programs and projects (WP1,8). Leverage previous EOOS efforts to engage key national contacts and build community support and interest.
Insufficient involvement of co-design with stakeholders leading to delays in the implementation of the BGC OSSE. **Low likelihood**	2, 4, 5, 6, 7, 8	Effective communication and engagement measures to increase involvement, based on the comprehensive stakeholder identification (WP8).
Insufficient engagement in integration activities, i.e. small participation to events and activities. **Low likelihood**	3	The group will be enlarged through invitations for participation to targeted events; adequate funds for invitation of experts is available.
Low Impact of EuroSea data assimilation in the CMEMS global, IBI and Med. **Low likelihood**	4, 3	Real-time observational data quality control modified, thinning of data carried out.
Insufficient engagement of stakeholders in adoption of novel systems in the demonstrators. **Low likelihood**	5, 6, 7	Make stakeholder engagement a priority action. We have well-established relationships with WP5,6,7 stakeholders and networks in WP3 will further assist the mitigation.

10 https://www.iprhelpdesk.eu/sites/default/files/newsdocuments/07%20Managing%20Impact%20and%20Innovation%20in%20H2020%20projects.pdf

Demonstrators fail to deliver new, marketable products. **Low likelihood**	5, 6, 7	The need for the proposed demonstrators are well researched. Interaction with WP8 will maximize the exploitation opportunities
Durability and legacy of capacity building with African partners. **Low likelihood**	5	The technological advances of the new systems reduce the need for complex maintenance. Significant new training will be delivered during this project and ongoing user engagement will come from improved global networks (WP3) and international organizations (e.g. IOC, WMO, GLOSS)
End-User products unfit for purpose leading to a lack of interest from end-users and insufficient participation in the co-development process. **Low likelihood**	6, 8	EuroSea has identified end-users for the proposed products and services and received a commitment guarantee from the co-developers to ensure services developed match the needs of end-users. Continuous user contact will ensure services provided are fit for purpose.
Miss timeline of CMEMS Ocean State Report activity for result implementation. **Low likelihood**	2, 4, 7	Close collaboration with CMEMS to anticipate and assure pre-planning for the implementation of results.
Inadequate input from the demonstrators on their individual exploitation plans. **Low likelihood**	5, 6, 7, 8	Coordination with WP8 from the outset, ensuring partners have access to appropriate analytical tools, templates and methodologies, as well as expertise across the project.
Lacking cooperation regarding responsible research and innovation (RRI). **Low likelihood**	all	Regular web and face-to-face meetings to evaluate the status of RRI in the demonstrator WPs and the entire project.
Best Practice in the project not developed to a sufficiently mature level. **Medium Likelihood**	1, 3, 5, 6, 7, 8	Utilize expertise in Ocean Best Practices team to guide WP leaders (particularly mid-project workshops for demo WPs towards project outcomes that constitute best practice.
Observing network activities finish after project lifetime. **Medium likelihood**	3	All networks will operate within EuroGOOS as task teams, fundraising activities to will be supported if needed to continuation of activities.
Delayed assessment of impact of EuroSea observations for satellite validation and CMEMS due to delayed demonstrator implementation and data integration. **Medium likelihood**.	4, 3, 5, 6, 7	Work with other sources of similar data to prepare the assessment tasks and switch to EuroSea data as soon as they are available
Malfunctioning interface between T4.2, 4.3, 4.4 with WP5 and 6 for usage of new products in the demonstrations. **Medium likelihood**	4, 5, 6	Technical meeting to discuss interfaces early in the project, devise a whole project strategy for inclusion of products into the demonstrations
Validation of satellite data not fully demonstrated and coordination with WP3 plan difficult to realize. **Medium likelihood**	4, 7, 8	Comprehensive stakeholder identification and advanced planning
Cessation of Services at end of project life due to insufficient resource planning. **Medium likelihood**	4, 6, 8	EuroSea will provide practical training to set-up, operate, maintain and interpret the data products; this will foster users to continue to maintain the *In Situ* system (e.g. fish farmers). EuroSea products and improved operational and environmental assessment products will be made available online. BOOS, HELCOM and CMEMS will work toward safeguarding this services.
Insufficient change in sustainability of the new system design and implementation tools due to inadequate funding and governance. **Medium likelihood**	1, 8	Clearly defined governance and sustainability plans supported by targeted communications enabling buy-in and engagement from relevant governance and funding bodies across both national and European levels.

3.3 Consortium as a whole

The EuroSea consortium consists of a complementary set of 55 partners representing **major research and operational institutions** from 14 European member states countries and 2 associated countries (Brazil and Canada)

engaged in **ocean observing or forecast**. The consortium includes 17 private companies, of which 9 are non-profit organizations (see section 4), and 10 third party organizations, providing in-kind contributions, that have expressed formal interest in cooperating with the consortium. The consortium also includes two intergovernmental organizations (IOC/UNESCO and WMO) with critical roles in coordination and governance of ocean observing.

The partners have been selected based on their excellence and expertise in all aspects **covering the complete value chain of ocean observing and forecasting:**

- *Coordination and requirement setting* at a European and international level (e.g. IOC/UNESCO, WMO, EuroGOOS, IO PAN (IOCCP), EMB, and IEEE);
- *Ocean observing system design* involving public and non-public entities with a long history of excellence and cooperation (e.g. MOI, CSIC, ENS, CLS, SOCIB IMT, OceanNext);
- *Observing Network Integration and Improvement* including 23 partners with documented excellence and expertise on the technical aspects of ocean observing but also with excellent track record of international cooperation needed for building an integrated system (e.g. HCMR, GEOMAR, MI, NIVA, Euro-Argo Eric, EMSO-Eric, UPORTO, SZN, AWI, ETT, CNR, WMO, OGS);
- *Data Integration and Forecasting* with leading European institutions and agencies represented (e.g. UNIBO, MOI, SOCIC, CLS, OGS, CMCC, SU, ECMWF, AZTI, ACRI);
- *Communication, Engagement, Dissemination, Exploitation and Legacy* involving world class institutions and private sector companies with a long record of cooperation (e.g. GEOMAR, EuroGOOS, MI, SOCIB, RBINS, ScienceEthics, and ISPRA).

EuroSea bring together excellent scientists with stakeholders and private enterprises engaged in ocean observing already providing services and contribute to technological innovation of the observing system and to generation of ocean information products. At a strategic level, in the governance structure of the project, we will establish an *exploitation board* that will support and monitor the project's innovation and exploitation activities to ensure that the potential of EuroSea activities is maximized. The *Innovation and Stakeholder Committee* (ISC, ref. Section 3.2.1) will engage the commercial sector in the "blue economy", e.g. ports, coastal communities, shipping, energy, fisheries, technology manufacturers, aqua culture, etc. The engagement of ocean related industries and stakeholders would be forged also for exploring new partnerships in ocean observing and forecasting. The combination of industrial key stakeholders in this committee will help to achieve specific measures proposed for exploitation of the results of the project. At a more operative level (work package level), we have built multidisciplinary teams involving the industrial sector. This is particularly evident in the three demonstration projects (**WP5,6,7**) where the whole value chain of ocean observing is exercised with focus on the generation of innovative products and services for stakeholders. One third party providing in-kind contribution to partner #7, INCAR (Interdisciplinary Center for Aquaculture Research, is from Chile. INCAR will co-develop products to identify local and regional impacts of oxygen, heat and pH related "*Extreme Marine Events*" and develop forecasting products for industry, government and scientific customers. Another third party providing in-kind contribution to partner #1, Saildrone Inc., is from the US. Saildrone Inc. will provide one of their autonomous surface vehicles to collect ocean data relevant for task 7.3. Saildrone Inc. is the only company globally that provides this all-inclusive maintenance service.

The gender distribution among WP leads is close to 50/50 and EuroSea will undertake actions during the course of the project to promote and ensure gender equality in the project. EuroSea is aware of the importance of attracting more high quality female researchers into ocean observing, and will ensure it acts upon the EC recommendations listed in the "Gendered Innovation" to stimulate and promote the progress of women in scientific careers. The Consortium will support equal participation between men and women in the implementation of the action and will aim to the extent possible for a gender balance at all levels of personnel assigned to the action, including at supervisory and managerial levels. The promotion and monitoring of gender equality throughout the project will be the responsibility of the Gender and Diversity Committee.

3.3.1 Other countries and International Organizations:

EuroSea comprises four trans-Atlantic partners, two from Brazil, Universidade do Estado do Rio de Janeiro (UERJ) and Universidade Federal de Pernambuco (UFPE), and two from Canada, Dalhousie University (DAL) and Memorial University of Newfoundland (MUN) and two international partners, the Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO) and the World Meteorological Organization (WMO). The four trans-Atlantic partners are involved in WP7. Both, DAL and MUN are active in T7.1, are intensively engaged, and support the Ocean Frontier Institute Canada (Research Excellence Fund plus private and public sector organizations) which represents Canada as a partner in EuroSea. UFPE and UERJ are both involved in task T7.3; here they will intensively contribute to the quantification of improvements in carbon flux data for the tropical Atlantic and to demonstration activity to obtain data based on different observational platforms and its dissemination pathways. The UN

organization IOC-UNESCO is an essential partner in EuroSea to enable best possible contribution to the development and demonstration of the feasibility of the European component of the Global Ocean Observing System (GOOS) in line with the G7 WG. IOC-UNESCO is one of the sponsors of GOOS and host the GOOS main office; within EuroSea this partner brings together the expertise, network, knowledge and best practices of GOOS, and the work through GOOS will support the EuroSea providing a global perspective. As such, IOC-UNESCO (GOOS) is co-leading EuroSea WP1. A second sponsor of GOOS is the UN organization WMO; JCOMM is the joint technical commission of these two UN organizations, and the host of JCOMMOPS that is leading for T1.2 (through IOC/UNESCO) and partner in T3.3 (through T3.3). The reason for involvement of both IOC/UNESCO and WMO is the funding structure of JCOMMOPS, and reflect the close connection GOOS and the importance of WMO for delivering to climate (WP7) and operational services (WP5).

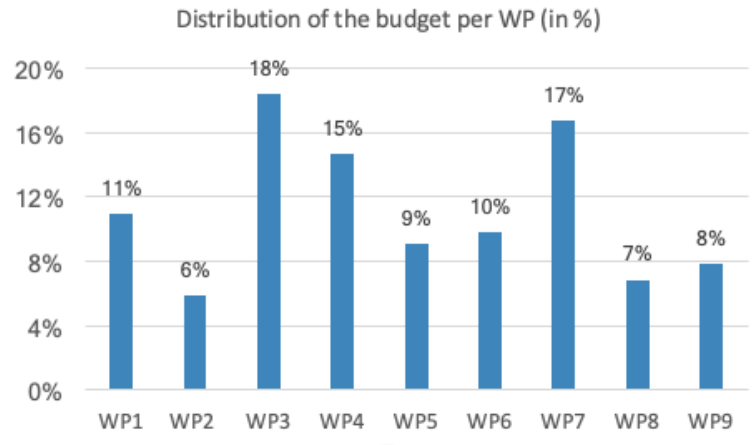
3.4 Resources to be committed

EuroSea will apply for a slightly higher (2%) budget than allocated in the call to undertake the requisite of a multi-disciplinary innovation action and to deliver the expected outcomes of this call. Accordingly, the total requested EC contribution amounts to € 12,266,772.50. The budget distribution in the different cost categories and their percentage shown in the table below. The percentage of funding to the partners with a 70% refunding rate is 7%.

Cost categories	**Personnel costs**	**Other direct costs**	**Subcontracting**	**Indirect costs**	**Total estimated costs**	**Maximum EU contribution**
Costs (€)	7,057,481 €	3,037,860 €	23,000 €	2,523,835 €	12,642,176 €	12,266,772 €
%	55.8%	24.0%	0.2%	20.0%	100.0%	97.0%

Personnel costs: The total amount of € 7,057,481.55 corresponds to estimated staff efforts of 1167.82 person-month (Table 3.4a). *This estimate does not consider that most partners will contribute expertise and staff time of permanent staff without requesting reimbursement*. The given personnel costs contribute to 55.8% of the total costs.

Other direct costs: These are mainly required for travel to project meetings, international conferences, and to invite experts to collaborate and co-design in all WPs to foster innovation of purposeful products through co-design. However, in the demonstration **WP5,6,7** and in **WP3** also other direct costs related to equipment and other goods and services to conduct the observations are needed to support the activities and host meetings to co-foster progressive cooperation and co-design. The coordinators budget covers resources for all external advisory board experts and for stakeholder events. The details of the split of other direct costs in the sub-categories (i) travel, (ii) equipment, and (iii) other goods and services is given in Table 3.4b for those partners that have other direct costs exceeding the personnel costs by 15%.



Subcontracting: the estimated costs for subcontracting are 0.2% of the overall budget. These costs are foreseen to contract an expert for intellectual property rights (IPR) for periodic advice on the business development plans to ensure comprehensive management of business plans and IPR. Details are given in section 4 of the proposal. The bar chart (Figure 7) provides an overview of the budget distribution to the different work packages.

Figure 7: *Cost distribution per WP*.

Table 3.4a: *Summary of staff effort*

	Partner	**WP1**	**WP2**	**WP3**	**WP4**	**WP5**	**WP6**	**WP7**	**WP8**	**WP9**	**Total PM**
1	GEOMAR	36	0	2	12	0	0	22	13	50.5	135.5
2	EuroGOOS	48							18.5		66.5
3	IOC-UNESCO	54					0.00				54
4	MOI		15		27.5			15			57.5
5	UNIBO				43						43
6	MI			5			28.43		15		48.43
7	CSIC		18.2	5.6	12.2		35.19				71.19
8	ENS		25.7								25.7

9	CLS		14.7		10.6						25.3
10	OGS			5.5	15						20.5
11	CMCC				25.5	14		12			51.5
12	UiB			15							15
13	UKRI			12.8		26					38.8
14	SU			6	1.5			13			20.5
15	SOCIB	4	5.5	24.5	20		6.2		15		75.2
16	ECMWF				12			12			24
17	IO PAN	20						5			25
18	IfW							8			8
19	Euro-Argo Eric			4				1			5
20	CNRS			21				16			37
21	IFREMER			6.2				9.8			16
22	RBINS								10		10
23	SciencEthics								12		12
24	ISPRA								2.9		2.9
25	IEEE	3									3
26	EMB	8									8
27	IMT		4								4
28	OceanNext		6.4								6.4
29	AZTI			14.5	6						20.5
30	EPPE			14.5	18	23					55.5
31	ACRI				9.5						9.5
32	ARUP					12					12
33	HCMR			2							2
34	NIVA			4							4
35	Met Office	5									5
36	EMSO-Eric			4							4
37	PLOCAN			8							8
38	UBREMEN			2							2
39	UPORTO			6							6
40	SZN			18							18
41	AWI			7							7
42	ETT			10							10
43	Nologin					22					22
44	UPC					20					6
45	DMI						13.00				13
46	TalTech						20.00				20
47	CNR			5.4							5.4
48	IRD							1			1
49	UCAM					13					13
50	Xylem						13.72				13.72
51	WMO			12							12
52	UERJ							0.0			
53	UEPR							0.0			
54	MUN							0.0			
55	DAL							0.0			
	Total	173	89.5	203.05	227.8	130	116.54	114.5	86.4	50.5	**1167.82**

Table 3.4b: *'Other direct cost' items (travel, equipment, other goods and services, large research infrastructure)*

1. GEOMAR	**Cost (€)**	**Justification**
Travel	296,000	Travels to annual meetings and international meetings for dissemination activities for PCU, WP3,8 leaders and WP3,7,8 task leaders. Travel and subsistence costs for experts including advisory board members participating

		in project meetings, conferences, and field experiments. Funds for engagement on a project level with international organizations and with the EC.
Equipment		
Other goods and services	239,000	Print services, catering for meetings, dissemination material, 4 GA meetings (room rent, catering etc.), pH/pCO2 sensors, consumables moorings (batteries, Wire, hardware), Operational costs for Wave Glider ASV mission (e.g., satellite telemetry, consumables; 7000 €) and charter costs for Saildrone ASV (reduced rate, 55000€)
Total	**535,000**	
2. EuroGOOS	**Cost (€)**	**Justification**
Travel	47,500	Travels to project meetings and international meetings for dissemination activities, travel assistance for workshops
Equipment		
Other goods and services	30,000	Website and dissemination materials design and production; meeting organization, service for workshops, moderator
Total	**78,000**	
3. IOC/UNESCO	**Cost (€)**	**Justification**
Travel	66,400	Travels to annual meetings and international meetings for dissemination activities, travel assistance for Workshops
Equipment		
Other goods and services	5,000	workshop logistics
Total	**71,400**	
4. MOI	**Cost (€)**	**Justification**
Travel	51,050	Travels to annual meetings and international meetings for dissemination activities
Equipment		
Other goods and services	27,000	Article publication fees, print service, workshop organization and catering
Total	**78,050**	
6. MI	Cost (€)	Justification
Travel	49,000	Travels to annual meetings, international meetings (dissemination activities), equipment installation and training at target sites, invitation of experts (e.g. the in-kind co-developers)
Equipment	36,000	pH sensor system for WP6
Other goods and services	7,000	calibration services and cable connectors, OA publication fees
Total	**Cost (€)**	**Justification**
7. CSIC		
Travel	38,845	Travels to annual meetings and international meetings for dissemination activities and equipment installation and training at target sites, invitation of experts (e.g. the in-kind co-developers)
Equipment		
Other goods and services	51,615	WP and cross WP Meetings organization, Article publication fees, elements and services necessary to adapt pH and other environmental sensors to Navigational Buoys, as well as the operation (batteries, telemetry communications)
Total	**90,460**	
8. ENS	**Cost (€)**	**Justification**
Travel	11,025	Travels to annual meetings and international meetings for dissemination activities
Equipment		
Other goods and services	15,000	WP and cross WP Meetings organization, Article publication fees
Total	**26,025**	
13. UKRI	**Cost (€)**	**Justification**
Travel	35,000	Travels to annual meetings and international meetings for dissemination activities, Travel and subsistence costs for participating in project meetings, conferences, and field experiments.

Equipment	222,000	Sea level measuring equipment (tide-gauges) for WP5: 4 Sea level sensors (25k each), 4 GNSS receiver (15k each). Llightning sensor, Meteorological instruments, Telemetry, (10k each), cabling, and diagnostic computer (22k)
Other goods and services		
Total	**257,000**	
14. SU	**Cost (€)**	**Justification**
Travel	26,000	Travels to annual meetings and international meetings for dissemination activities
Equipment		
Other goods and services	85,000	organization of 2 meetings, pH sensor system (single use do to application in harsh environment)
Total	**111,000**	
17. IO PAN	**Cost (€)**	**Justification**
Travel		Travels to annual meetings and international meetings for dissemination activities
Equipment		
Other goods and services		Print services, catering for meetings
Total	**35,000**	
19. Euro-Argo Eric	**Cost (€)**	**Justification**
Travel	46,000	Travels to annual meetings and international meetings for dissemination activities
Equipment	485,000	5 DEEP Argo floats (160k€), 5 BGC Ago floats (pH, O2, chl-a, susp. particles, downward irradiance, 325k€) for WP7
Other goods and services	70,000	Room renting, catering for meetings, Transmission costs
Total	**601,000**	
20. CNRS	**Cost (€)**	**Justification**
Travel	55,000	Travels to annual meetings and international meetings for dissemination activities, T3.3 meetings invitations
Equipment		
Other goods and services	56,000	Print/publication services, room rental, catering for meetings, glider functioning (satellite communication, batteries), water sample analyses, pH/pCO2 sensors (single use do to application in harsh environment)
Total	**111,000**	
21. IFREMER	**Cost (€)**	**Justification**
Travel	60,100	Travels to annual meetings and international meetings for dissemination activities
Equipment		
Other goods and services	10,000	Room renting, catering for meetings
Total	76,100	
24. ISPRA	**Cost (€)**	**Justification**
Travel	18,300	Travels to annual meetings and international meetings for dissemination activities
Equipment		
Other goods and services		
Total	**18,300**	
25. IEEE	**Cost (€)**	**Justification**
Travel	10,000	Travel to annual meetings and international meetings
Equipment		
Other goods and services	14,000	E84 web services, advocacy and outreach
Total	**24,000**	
26. EMB	**Cost (€)**	**Justification**
Travel	12,500	Travel to annual meetings and international meetings, travel assistance for workshops
Equipment		
Other goods and services	7,500	Service for workshops, moderator

Total	**20,000**	
29. AZTI	**Cost (€)**	**Justification**
Travel	38,000	Travels for workshops participants (32k€) + travels to annual meetings and international meetings for dissemination activities for AZTI Team (3k€)
Equipment		
Other goods and services		
Total	**38,000**	
30. EPPE	**Cost (€)**	**Justification**
Travel	45,800	Travels to annual meetings and international meetings for dissemination activities
Equipment		
Other goods and services		
Total	**40,800**	
33. HCMR	**Cost (€)**	**Justification**
Travel	30,000	Travels to annual meetings and international meetings for dissemination activities
Equipment		
Other goods and services		
Total	**30,000**	
34. NIVA	**Cost (€)**	**Justification**
Travel	33,000	Travels to annual meetings and international meetings for dissemination activities
Equipment		
Other goods and services	2,000	Print services, catering for meetings
Total	**35,000**	
35. Met Office	**Cost (€)**	**Justification**
Travel	17,500	Travels to annual meetings and international meetings
Equipment		
Other goods and services		
Total	**17,500**	
36. EMSO-Eric	**Cost (€)**	**Justification**
Travel	10,000	Travels to annual meetings and international meetings for dissemination activities
Equipment		
Other goods and services		
Total	**10,000**	
37. PLOCAN	**Cost (€)**	**Justification**
Travel	60,000	Travels for workshops participants (45k€) + travels and subsistence for PLOCAN team to attend project meetings, field experiments and international meetings for dissemination activities (15k€)
Equipment		
Other goods and services	8,000	Workshop organization (catering, transport, dissemination services, etc.)
Total	**68,000**	
38. UBREMEN	**Cost (€)**	**Justification**
Travel	5,000	Travel and subsistence costs for participating in project meetings, conferences, and field experiments.
Equipment		
Other goods and services	2,000	Support of commonly organized field missions, communication costs, transport etc.
Total	**7,000**	
39. UPORTO	**Cost (€)**	**Justification**
Travel	6,000	Travel and subsistence costs for participating in project meetings, conferences, and field experiments.
Equipment		
Other goods and services	4,820	Components, consumables, and services

Total	**10,820**	
40. SZN	**Cost (€)**	**Justification**
Travel	10,000	Travels to annual meetings and international meetings for dissemination activities
Equipment		
Other goods and services	65,000	Network meeting, consumables and sequencing for protocols testing and pilot project.
Total	**75,000**	
41. AWI	**Cost (€)**	**Justification**
Travel	10,000	Travels to annual meetings and international meetings for dissemination activities
Equipment		
Other goods and services	40,000	consolidation workshop
Total	**50,000**	
42. ETT	**Cost (€)**	**Justification**
Travel	8,000	Travels to annual meetings and international meetings for dissemination activities
Equipment		
Other goods and services		
Total	**8,000**	
45. DMI	**Cost (€)**	**Justification**
Travel	20,000	4 general assembly meeting, 2 working meetings
Equipment		
Other goods and services		
Total	**20,000**	
48. IRD	**Cost (€)**	**Justification**
Travel	3,000	Travels to annual meetings and international meetings for dissemination activities
Equipment		
Other goods and services	70,000	Sensor calibration and shipping cost, CARIOCA sensor single use do to application in harsh environment
Total	**73,000**	
50. Xylem	**Cost (€)**	**Justification**
Travel	13,000	Staff travel costs (fieldwork and meetings)
Equipment	94,500	Integrated In-Situ buoy system (buoy, sensors, data loggers, modem etc.)
Other goods and services	8,000	cables etc.
Total	**115,500**	
51. WMO	**Cost (€)**	**Justification**
Travel	39,000	Travels to annual meetings and international meetings for dissemination activities
Other goods and services	2,000	Print services, catering for meetings
Equipment		
Total	**41,000**	