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Agenda item 7: Status of implementation of the Ecosystem Approach (EcAp) Roadmap

7.2. Status of implementation of the ODYSSEA project on Mediterranean observatories

The ODYSSEA project: Opportunities for supporting the Integrated Monitoring and Assessment Programme (IMAP) through integrated marine observing systems, capacity building and information services

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Executive Summary

The European Union Horizon 2020 funded ODYSSEA project ('Operating a network of integrated observatory systems in the Mediterranean Sea') (www.odysseaplatform.eu) is establishing an interoperable, user-driven platform which integrates data from networks of observing and forecasting systems with in-situ data collected from across the Mediterranean Sea, including from nine observatories established as part of the project. The platform is called Marinomica Platform (https://marinomica.com). By facilitating access to data and tailored information services, the Marinomica Platform aims to support decision-making for a sustainable blue economy and effective conservation of ecosystems and biodiversity in the Mediterranean Sea.

This document summarises how ODYSSEA's integrated marine observing systems, capacity building and information services can support national monitoring efforts under the Integrated Monitoring and Assessment Programme (IMAP) of the United Nations Environment Programme Mediterranean Action Plan (UNEP/MAP), and how it can continue to do so through the Marinomica Platform. ODYSSEA is implemented by a Consortium of 28 partners from 14 countries, also including UNEP/MAP-SPA/RAC and UNEP World Conservation Monitoring Centre (UNEP/WCMC), which compiled this information document on behalf of the Consortium. ODYSSEA is now in its final year of implementation, ending in November 2021.

Data collected through the ODYSSEA project and presented on the Marinomica Platform has the ability to fill some of the current knowledge gaps in the Mediterranean Sea region in relation to IMAP, the European Union Marine Strategy Framework Directive descriptors and Essential Ocean Variables. Notably, the three thematic clusters of the Mediterranean Quality Status Report, under which the 11 Ecological Objectives are organised – 1) land and sea-based pollution, 2) biodiversity and ecosystems, 3) land and sea interactions and processes – align with the priority areas for data collection and modelling under ODYSSEA. These are pollution (including marine litter, oil spills and eutrophication), biodiversity (including fish stocks, marine mammals and invasive species), and hydrographic and coastal processes.

In the medium-term, data and services available on the Marinomica Platform could contribute to the preparation of the next Mediterranean Quality Status Report in 2023. In the long-term, ODYSSEA Observatories can provide data to support Contracting Parties in their national monitoring efforts under IMAP.

The review of best practices and priority knowledge needs for the science-policy interface for IMAP shows that activities under ODYSSEA are contributing to building capacity in the Mediterranean Sea region, fostering partnerships and facilitating access to data and monitoring tools.

Contents

1. Introduction to the report

This document provides a progress update on the ODYSSEA project and summarises how ODYSSEA's integrated marine observing systems, capacity building and information services can support national monitoring efforts under the Integrated Monitoring and Assessment Programme (IMAP) of the United Nations Environment Programme Mediterranean Action Plan (UNEP/MAP).

1.1. Update on the ODYSSEA Project

The European Union Horizon 2020 funded ODYSSEA project ('Operating a network of integrated observatory systems in the Mediterranean Sea') (www.odysseaplatform.eu) is establishing an interoperable, user-driven platform which integrates data from various networks of observing and forecasting systems with in-situ data collected from across the Mediterranean Sea. The platform is called Marinomica (https://marinomica.com). By facilitating access to data and tailored information services, the Marinomica Platform aims to support decision-making for a sustainable blue economy and effective conservation of ecosystems and biodiversity in the Mediterranean Sea. Anticipated end-users include the public sector, industry and conservation, as well as members of the public, education and research institutions.

The ODYSSEA project has made substantial progress since its inception in June 2017. Key milestones achieved since the project started include:

- Establishment of nine Observatories, with in situ data collection for a range of parameters (see Section 2)
- Thirty targeted end-user engagement and capacity building activities including a series of training workshops and summer schools (see Section 3)
- Launch of the beta version of the Marinomica Platform (https://marinomica.com)
- Development of Marinomica services and products, addressing coastal erosion, jellyfish invasions, wave energy and water quality (see Section 4)
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ODYSSEA is now in its final year of implementation, as the project ends in November 2021. The products and services developed by the project will continue to be available beyond the project on the Marinomica Platform.

1.2. Supporting policy processes through ODYSSEA

A key objective of ODYSSEA is to support policy processes in the Mediterranean Sea region, such as IMAP. In 2018, ODYSSEA partners conducted a detailed analysis of the key knowledge gaps identified in the 2017 Mediterranean Quality Status Report (for more information see https://doi.org/10.1016/j.scitotenv.2019.02.417). The gap analysis found that ODYSSEA data and models could contribute to filling some of the current knowledge gaps for 12 IMAP Common Indicators, supporting more comprehensive and integrated monitoring of seven Ecological Objectives. The findings of the gap analysis are summarised in Section 5 of this progress report. Given the close links and the synergy between the European Union Marine Strategy Framework Directive (MSFD) and IMAP, these potential contributions would also support the objectives of the MSFD (Section 6), and assist monitoring of Essential Ocean Variables (EOVs) as defined by the Global Ocean Observing System (GOOS) (Section 7). Section 8 summarises how ODYSSEA can support efforts to establish a strong science-policy interface for IMAP, as identified as part of the EcAp MED II project.

2. The ODYSSEA Observatories

ODYSSEA has established nine pilot Observatories around the Mediterranean Sea. Four Observatories are in North Africa, three in the Eastern Mediterranean (Aegean and Levantine Sea), one the Northern Adriatic Sea and one on the Valencia coastline.

2.1. ODYSSEA sensor systems

A range of mobile and static sensor systems are being deployed at the ODYSSEA Observatories. The data collected will fill existing data gaps and increase the temporal and spatial resolution of observational and forecasting data in the Mediterranean Sea (Table 1). To date, five glider missions, three surface sensors and one seafloor lander have been deployed (Table 2). Three more surface sensors and one lander will be deployed over the course of 2021.

Table 1: ODYSSEA sensor systems and the data they provide

Type	System	Sensor	Data
Glider	Glider Payload 1	GPCTD + DO	Conductivity, Temperature, Dissolved Oxygen
		FLBBCD	Chlorophyll *a* Fluorescence (proxies of phytoplankton abundance), Backscattering (total particle concentration), CDOM Fluorescence (coloured dissolved organic matter)
	Glider Payload 2	Acoustic sensor	Passive acoustic monitoring
	Glider payload 3	CTD + Microplastic	Microplastic count and classification
Seafloor Lander	Modular Seafloor Lander type A x1	Neptune Sonar Hydrophone	Acoustic signal
		ADCP	Current profile
		Aanderaa 4531	Dissolved Oxygen, Temperature
		Aanderaa 4319B	Conductivity, Temperature
		Cyclops 7F	Chlorophyll *a* Fluorescence
	Modular Seafloor Lander type B x1	Neptune Sonar Hydrophone	Passive acoustic monitoring
		ADCP	Current profile
		Aanderaa 4531	Dissolved Oxygen, Temperature
		Aanderaa 4319B	Conductivity, Temperature
		Cyclops 7F	Chlorophyll *a* Fluorescence
		Microplastic	Microplastic count and classification
Surface Monitoring	Surface monitoring type A x1	Aanderaa 4531 D	Dissolved Oxygen, Temperature
		Aanderaa 4319B	Conductivity, Temperature
		Cyclops 7F	Chlorophyll *a* Fluorescence
		DW.CAM	Camera and lights
		Microplastic	Microplastic count and classification
	Surface monitoring type B x1	Aanderaa 4531	Dissolved Oxygen, Temperature
		Aanderaa 4319B	Conductivity, Temperature
		Cyclops 7F	Chlorophyll *a* Fluorescence
		DW.CAM	Camera and lights
		Aanderaa 4531	Cyclops 7F

Type	System	Sensor	Data
	Surface monitoring type C x5	Aanderaa 4319B	Conductivity, Temperature
		Cyclops 7F	Chlorophyll *a* Fluorescence

Table 2: Overview of sensor implementation status for each observatory (Green = Deployed and Operated; Yellow = To Be Deployed Soon; Orange = To Be Deployed This Year (2021); (White = Deployment not planned). For further detail about implementation status at each Observatory, see Table 5.

Observatory	Country	Glider	Surface System	Seafloor Lander
Thracian Sea	Greece			
Gulf of Goköva	Turkey			
Valencia	Spain			
Northern Adriatic Sea	Italy			
Gulf of Arzew/Stora Bay	Algeria			
Gulf of Gabes	Tunisia			
National Park Al-Hoceima	Morocco			
Israel Coastal	Israel			
Nile River Region of Freshwater Influence	**Egypt**			

2.2.ODYSSEA modelling systems

The Observatories are also running high-resolution operational models. Descriptions of the models are provided in Table 3 and their implementation by the observatories in Table 4. The main modelling interfaces used by the ODYSSEA Project are the Delft-FEWS and the AQUASAFE systems. Delft-FEWS (www.deltares.nl) is an open-source data platform for operational flood forecasting, created in 2003 with funding from the Dutch government. It has modules that can be customised to specific requirements and is used in over 40 operational centres. The AQUASAFE platform, developed by HIDROMOD, integrates measured data (from sensors, remote detection, etc.) and modelled data (waves, hydrodynamic, water quality, meteorology, etc.) and offers data analytics capabilities to transform data into information. The analyses provided by AQUASAFE can be tailored to different users, for example providing wave and current forecasting for ports and shipping. AQUASAFE and Delft-FEWS are the tools used to interlink models, import initial and boundary conditions, execute the model chain, and visualize results on the Marinomica Platform.

Table 3: Description of ODYSSEA modelling systems

Model	Summary
Delft3D-FLOW / MOHID	Multi-dimensional hydrodynamic simulation program, which calculates non-steady flow and transport phenomena that result from tidal and meteorological forcing. It provides the hydrodynamic basis for other modules such as water quality, ecology, waves, and morphology.
Delft3D-WAVES / SWAN	Simulates the propagation of wind-induced waves over the observatory areas, computing wave propagation, wave generation by wind, non-linear wave-wave interactions, and dissipation.

Model	Summary
DELWAQ / MOHID	This model combines components from the hydrodynamic and the biological models, which includes an array of modules reproducing water quality processes that are then combined with the transport model. This model most importantly calculates primary production and Chlorophyll-a concentration while integrating dynamic process modules for dissolved oxygen, nutrient availability, and phytoplankton species.
ECOPATH	ECOPATH models represent a static, mass-balanced snapshot of the studied ecosystem. The ECOPATH software package can be used in order to: a) address ecological questions, b) evaluate ecosystem effects of fishing, c) explore management policy options, d) analyse impact and placement of marine protected areas, e) model effect of environmental changes.
OpenOil	OpenOil is a marine surface oil spill model designed to simulate oil slick transport and transformation processes for realistic oceanic cases.
Mussel Farm Population Dynamics	This model uses biological and environmental parameters to progressively calculate filtration rate, ingestion, assimilation, respiration, and net production, resultantly calculating mussel somatic growth and reproduction.
Coastal erosion	This model computes the incident on the coast wave energy. In parallel, it utilizes historic satellite imagery, uses trained Machine Learning algorithm to extract past shorelines and derives a series of statistical indicators on shoreline evolution.
Jellyfish	Using numerical modelling tools, the behaviour of jellyfish can be simulated, and their horizontal and vertical migration can be predicted. These predictions may include the likelihood of jellyfish spatial and temporal distributions and potential stranding locations before they reach the coast in touristic areas. Within the ODYSSEA project, an individual-based model (IBM) was developed to simulate the life cycle of the mauve stinger (*Pelagia noctiluca*) from the fertilized egg stage to the adult stage. This IBM combines available biological and behavioural knowledge on the mauve stinger with freely available hydrodynamic fields from the Copernicus Marine Environment Monitoring Service (CMEMS). Current developments focus only on the mauve stinger, but the model can be adapted to other species.
Wind Energy	The wind energy model retrieves the historical Copernicus Marine Service (CMEMS) wind products derived by blending satellite (scatterometers) and atmospheric numerical models (ERA5 Interim) and computes the wind energy potential per directional bin at each study area.

Table 4: Overview of model implementation status for each Observatory (Green = fully implemented; Orange = in progress; White = not envisioned).

Observatory	Country	Hydro	Wave	Water	Ecosyst	Oil	Mussel	Erosion	Jellyfish	Wind
Thracian Sea	Greece									
Gulf of Gökova	Turkey									
Valencia	Spain	*Valenciaport has its own such monitoring program*								
Northern Adriatic Sea	Italy									
Gulf of Arzew/ Stora Bay	Algeria									
Gulf of Gabes	Tunisia									
National Park Al-Hoceima	Morocco									
Israel Coastal	Israel									
Nile River Region of Freshwater Influence	Egypt									

Mediterranean Sea Scale

In addition, a fish Species Distribution Model (SDM) was developed for the Mediterranean distribution of *Engraulis encrasicolus, Sardina pilchardus, Sardinella aurita, Scomber colias, Scomber scombrus, Spicara smaris, Thunnus thynnus* and *Xiphias gladius*, utilizing AquaMaps probability of occurrence data and implementing a novel machine-learning model based on oceanographic and environmental parameters.

2.3. Overview of all ODYSSEA data collection activities

Table 5 provides a summary of the data being collected at the ODYSSEA Observatories through the deployment of sensor and modelling systems outlined above.

Table 5: Summary of sensor and modelling systems collected by the nine ODYSSEA Observatories

Observatory	Sensor systems	Modelling systems
Thracian Sea (Greece)	Three Glider missions successfully completed. Glider data collected: Chlorophyll-a, BB-700, CDOM, conductivity, temperature, pressure, dissolved oxygen, acoustic. Surface sensor deployed at mussel farm at surface, Olimpiada, western Thracian Sea. Surface data collected: Dissolved oxygen, air saturation, water temperature, conductivity, chlorophyll-a, turbidity. Seafloor Lander deployed at the Energean Oil and Gas rig (55m depth). Lander data	Hydrodynamic, Wave, water quality, oil spill, mussel growth, coastal erosion, wind energy

Observatory	Sensor systems	Modelling systems
	collected: Dissolved oxygen, air saturation, water temperature, conductivity, chlorophyll-a, turbidity, current speed, current direction.	
Gulf of Gökova (Turkey)	Surface system will be deployed at a small marina at 24m depth, Gökova Bay, South Aegean Sea. Expected launch date: June 2021. Data to be collected: Temperature, salinity, conductivity, dissolved oxygen, chlorophyll-a.	Hydrodynamics, Wave, Ecosystem Planned: Water Quality, wind energy
Valencia Coastline (Spain)	Spain is not deploying ODYSSEA sensor systems but has developed and applied in collaboration with Deltares the alien invasive species monitoring tool. VPORTS is progressing with the port sample protocol. Spain is conducting a port survey protocol for defining the baseline and early detection of invasive species.	Coastal erosion, jellyfish, biodiversity protection, early detection of alien invasive species, ballast water Planned: Wind energy
North Adriatic Sea (Italy)	Microplastic surface sensor system deployed March 2020. Data collected: Microplastics.	Hydrodynamics, water quality Planned: Wind energy
Arzew Bay/Stora Gulf (Algeria)	Algeria is not deploying sensor systems.	Hydrodynamics, Wave, Water Quality Planned: Wind energy
Gulf of Gabes (Tunisia)	Two surface systems to be deployed in May 2021 and June 2021. Data to be confirmed. Glider to be deployed in 2021 in collaboration with Malta university.	Hydrodynamics, Wave Planned: Water quality, Wind energy
Al-Hoceima (Morocco)	Two glider missions completed: 1) November 10 to December 11, 2020 (30 days); 2) February 11 to March 23, 2021. Glider data collected: Conductivity, pressure, temperature. Surface and lander systems to be deployed in 2021.	Hydrodynamics, Wave, Water Quality, Ecosystem, coastal erosion Planned: Wind energy
Israel coastline (Israel)	Surface system deployed at fish cages 12km offshore Ashdod, Southern part of the coast in January 2021. Data collected: Dissolved oxygen, conductivity, temperature, turbidity, chlorophyll-a, microplastic, currents profile down to 40m. Glider to be deployed in 2021.	Hydrodynamics, Wave, Water Quality oil spill, coastal erosion Planned: Wind energy
Nile River Region of Freshwater Influence (Egypt)	Egypt is not deploying sensor systems.	Hydrodynamics, Wave Ecosystem, coastal erosion Planned: Water Quality, wind energy

3. Capacity building in Northern Africa

The ODYSSEA project aims to make data and information on the Mediterranean Sea easily accessible for decision-making by many different users. This requires providing the data and information services through the Marinomica Platform, and also enabling decision makers to use them. Capacity building is a key component of the ODYSSEA project, with a particular focus on Northern African countries. Over the last four years, ODYSSEA partners have organized a series of training workshops and summer schools on topics ranging from using the ODYSSEA models and sensor equipment to oceanography more broadly. Table 6 gives an overview of these events.

Table 6: Overview of training workshops and summer schools organised under the ODYSSEA project

When and where	What
Heraklion, Greece **5-9 March 2018**	Training workshop on Delft-FEWs and Delft3D modelling suite. The aim of the workshop was to train participants on setting up and running of operational hydrodynamic, wave and water quality models for the Observatories.
Thessaloniki, Greece **3-5 July 2018**	Workshop to train the ODYSSEA Observatory Personnel in setting up ECOPATH models and addressing potential data issues.
Kavala, Greece **September 2018**	ODYSSEA organized its 1st Summer School on Operational Oceanography for Science, Business and Society. 10 North African young scientists were supported to enable their participation at summer school
May 2019, France **July 2019, Germany**	Training workshops were held for Observatory Managers on marine monitoring equipment: Glider (Alseamar) and sensor systems (Develogic).
Alonissos, Greece **2-6 September 2019**	ODYSSEA organized its 2nd summer school on Oceanography and Fisheries in the Mediterranean. Two North African young scientists were supported to enable their participation. During the summer school, focus was especially dedicated to Ecopath-Ecosym modeling and in-situ data collection.
Malta **January 2020**	ODYSSEA partners participated at the Malta International Winter School 2020: Oceanography and the Blue Economy, giving lectures on coastal operational observing systems for ecosystem assessments and on Modelling.
Online **7 October 2020**	Workshop for Tunisian stakeholders (including public institutions, academics and researchers in marine sciences, public and private operators in the field of maritime transport, fishing, and aquaculture), presenting the tools of the Marinomica Platform.
Online **23-27 November 2020**	The 3rd ODYSSEA summer school focused on operational oceanography from space with contributions from EUMETSAT and LEGOS.
Online **15 March 2021**	A Virtual Webinar on DELWAQ water Quality Modelling was organized by Deltares and FORTH. This presented the concepts of water quality modelling and of DELWAQ, highlighting the data needed and the selection of processes and parameters for setting up the water quality models in Observatories.
In person and online **22-24 February 2021**	Training workshop on "Geospatial Analytics and Remote Sensing for Climate Change Impact on Marine and Coastal Ecosystems" for users in Egypt.
To be held on online **2-3 June 2021**	ODYSSEA partners are preparing a workshop dedicated to Moroccan end-users under the title "Platform User Validation & Operational Oceanography Workshop".

4. Marinomica products and services

The data and services generated by the ODYSSEA project will be made available and further developed on the Marinomica Platform (https://marinomica.com). A sustainable business strategy is currently being developed to maintain this platform in the long-term.

The platform provides historical time-series, real-time data and forecasts for oceanographic and sea water quality parameters, based on Earth Observation monitoring (satellites, argo floats, gliders, buoys) and prognostic models. Advanced algorithms are applied to organise, homogenise and fuse the large quantities of data into a common standard type in a user-friendly manner. This section summarizes four key products and services that are being developed for the Marinomica Platform.

4.1. Water quality assessment and forecasting

The Marinomica Platform provides high-resolution data and forecasts for sea water quality parameters. This includes the trophic state index TRIX, a water quality score characterising coastal areas in terms of their eutrophication state. This index uses the concentration of chlorophyll-a, along with dissolved inorganic nitrogen, total phosphorus and the deviation of dissolved oxygen content from saturation, to determine trophic state.

The Marinomica service provides historical TRIX time-series and operational forecasts (2 days ahead, updated daily). Maps and graphs are shown for each pixel point of coastal, near- and offshore areas. The dashboard function on the Marinomica Platform allows users to customise data and information. This makes it possible to observe TRIX values in specific areas and set up alerts for when TRIX values are either above or below set values.

4.2. Jellyfish forecasts

The jellyfish forecast service that is currently under the development will provide alerts for jellyfish invasions in specific areas. Forecasts of where jellyfish will be stranded will be shown on maps and an early warning system will allow users to avoid or prepare for mass jellyfish stranding. Jellyfish invasions can cause considerable disruption and economy loss for recreation and tourism operators, coastal power plants located that frequently experience issues related to jellyfish clogging water-cooling systems, and fish farms where jellyfish can cause fish deaths and block cleaning pumps and filters. Disruptions such as these can be prevented through advanced notice of large jellyfish swarms. For more information, please see: https://doi.org/10.1016/j.ecolmodel.2020.109230.

4.3. Wave Energy Assessment

Marinomica provides daily updated maps on the distribution of wave energy (in kW/m) for offshore and onshore areas. Wave energy is calculated using the results of numerical wave models, particularly significant wave height, wave period and wavelength. These wave models have been calibrated and validated against on-site wave data, deployed by many organizations and the ODYSSEA Consortium. Marinomica maps can inform decision-making in relation to waves as a source of marine renewable energy in the Mediterranean, aiming to assist potential investors on site selection, historic wave energy time-series and short-term forecasts.

4.4. Coastal erosion monitoring

The ODYSSEA project has developed a novel methodology combining satellite image analysis, geostatistical processing, historic wave data analysis and ray-wave model implementation to:

a) identify coastal erosion ‘hotspots’ along the shoreline,

b) estimate incident wave energy per coastline segment,
c) assess the long-shore and cross-shore components of sediment transport and,
d) aid the improvement in the design of coastal protection works along the Mediterranean coastline.

An algorithm has been developed to retrieve historical satellite imagery, process the images to extract the historic shorelines and assess shoreline evolution over the examined period. A series of metrics and statistical indices is used to assess coastal erosion and identify 'erosion hotspots', such as the Net Shoreline Movement (NSM, m/yr), the End Point Rate (ERP, m/yr) and the Weighted Linear Regression (WLR, m/yr). At the identified coastal erosion hotspots, the algorithm retrieves from the Marinomica Platform the incident to the coast wave energy and evaluates the processes (along-shore or cross-shore) responsible for coastal erosion. Through this toolkit, better and more effective mitigation measures may be designed and implemented along the Mediterranean coastal zones.

5. Alignment between ODYSSEA and policy frameworks in the Mediterranean Sea

ODYSSEA seeks to support policy processes in the Mediterranean Sea region, such as IMAP and the European Union Marine Strategy Framework Directive (MSFD). An overview of how ODYSSEA data and models align with IMAP, the MSFD, as well as the Global Ocean Observing System (GOOS) Essential Ocean Variables (EOVs), is presented in Annex 1-3.

Annex 1 summarises the key IMAP knowledge gaps identified in the 2017 Mediterranean Quality Status Report, and how these gaps could be addressed by relevant ODYSSEA data and models. The table is organised by IMAP Ecological Objectives and Common Indicators and includes links to the relevant sections of the 2017 Mediterranean Quality Status Report (2017 MED QSR).

Annex 2 summarises how ODYSSEA's potential contributions align with the 11 MSFD descriptors that monitor 'good environmental status' (as described in European Commission decisions decision 2010/477/EU and decision 2017/848/EU).

Annex 3 gives an overview of how current efforts under ODYSSEA are aligned with the EOVs, and for which MSFD Descriptors and IMAP Ecological Objectives these EOVs are relevant. Moving forward, this will allow identification of areas in which interoperability could be improved.

6. Supporting the science-policy interface for IMAP

In 2016-17, a series of workshops were co-organised by UNEP/MAP MED POL, SPA/RAC and Plan Bleu under the EcAp Med II project[1]. The workshops identified priority knowledge needs and recommended actions to strengthen the science-policy interface for the implementation of IMAP regarding pollution (EO5 Eutrophication, EO9 Contaminants), biodiversity (EO1 Biodiversity, EO2 Non-indigenous species) and marine protected areas. Many of the priority science-policy knowledge needs are reflected in the IMAP knowledge gaps identified from the 2017 MED QSR and could be supported by ODYSSEA data and models (see Annex 1). One of the workshops also identified a number of best practices for successful science-policy interfaces. ODYSSEA is showcasing how these best practices can be implemented and contribute to strengthening the science-policy interface for IMAP (Table 7).

Table 7: Summary of best practices for science-policy interfaces and how these are being implemented in the ODYSSEA project (source: Report of the Meeting "Workshop on Science Policy Interface (SPI) strengthening for the implementation of the UNEP/MAP Integrated Monitoring and Assessment Programme, for Pollution", Marseille 20-21 October 2016)

Best Practice for science-policy interfaces	The ODYSSEA project…
Structure **Adapted to the context at different levels (local, national, regional).** **Creating links between scientific community and policy makers/public institutions to set up networks of experts and projects for specific issues.** **Includes performance evaluation.**	Is building partnerships and connecting scientific research institutions with policy makers and public institutions at local, national and regional level
Communication **Clear and simple messages from scientists and policy makers.** **Integration of different stakeholders in a multilateral debate.** **Training to enable scientific experts to 'translate' academic/scientific results into policy advice on socioeconomic issues.** **Continuous and effective dialogue with the media.**	Is developing a platform that will facilitate access to scientific information for policy makers and decision makers in public institutions (primary data will be processed and packaged into tailored information services for different user groups) Is involving different stakeholders in the development process
Time considerations **Recognition that scientific experts and policy makers operate on different time schedules.** **Scientists need to find best possible ways to regularly inform policy makers about environmental change.** **Recognition of increasing pressure on scientists from growing political demand for scientific advice.**	Will provide information on different timescales to meet different decision-making needs (daily updates, historical data, forecasts, automated modelling processes)
Resource allocation **Integrate science-policy interface processes into research projects.** **Capitalise on existing scientific expertise.** **Need data and knowledge efficiency for monitoring.**	Provides resources and opportunities for science policy interactions Is drawing on existing expertise and building new monitoring capacity

[1] EcAp Med II (2015-2019) is the second of two projects to support the implementation of the ecosystem approach in the Mediterranean Sea. More information available at: http://www.rac-spa.org/ecapmed_ii.

7. Conclusion

The Marinomica Platform and Observatories are expected to be fully operational by the end of the ODYSSEA project in November 2021, with the aim to continue operating self-sustained after this. The alignment with IMAP knowledge gaps, MSFD descriptors and EOVs presented here suggests that the data and information services provided by Marinomica and the nine Observatories could contribute to filling some of the current knowledge gaps in the Mediterranean Sea region and support more comprehensive and integrated monitoring.

Notably, the three thematic clusters of the Mediterranean Quality Status Report, under which the 11 Ecological Objectives are organised – 1) land and sea-based pollution, 2) biodiversity and ecosystems, 3) land and sea interactions and processes – align with the priority areas for data collection and modelling under ODYSSEA – biodiversity (including fish stocks, marine mammals and invasive species), pollution (including marine litter, oil spills and eutrophication), hydrographic and coastal processes.

In the medium-term, data and services available on the Marinomica Platform could contribute to the preparation of the next Mediterranean Quality Status Report in 2023. In the long-term, if the ODYSSEA Observatories can be established as a reliable and quality assured data source, the data they provide could support the respective Contracting Parties in their national monitoring and assessment efforts under IMAP.

Moreover, the review of best practices and priority knowledge needs for the science-policy interface for IMAP shows that activities under ODYSSEA are contributing to building capacity on this in the Mediterranean Sea region by:

- Increasing the spatial and temporal coverage of monitoring of various parameters, for which data gaps currently exist,
- Building capacity for data collection and processing (including modelling tools),
- Enabling partnerships and connecting scientific research institutions with policy makers and public institutions at local, national and regional level,
- Facilitating access to scientific information for policy makers and decision makers in public institutions.

Annex 1: Alignment between IMAP knowledge gaps and ODYSSEA data

Table A1 summarises the key IMAP knowledge gaps identified in the 2017 Mediterranean Quality Status Report, and how these gaps could be addressed by relevant ODYSSEA data and models. The table is organised by IMAP Ecological Objectives and Common Indicators and includes links to the relevant sections of the 2017 Mediterranean Quality Status Report (2017 MED QSR).

Table A1: Summary of IMAP knowledge gaps and ODYSSEA data and models

Ecological Objective (EO)	Common Indicator (CI)	Knowledge gaps (identified in the 2017MED QSR)	ODYSSEA data and models	
			ODYSSEA's relevant data parameters	Sensor or modelling system(s)
Biodiversity and Ecosystems (EO1)	Species distributional range – Marine Mammals (CI3 MM)	Marine mammal species distribution ranges, particularly for southern Mediterranean countries	Marine mammal species recognition and distribution	Glider Payload 2
				Modular Seafloor Lander type A/B
	Species distributional range – Marine Reptiles (CI3 MR)	Marine turtle species distribution ranges, including breeding, nesting, wintering, feeding and developmental sites	*Potentially marine turtle distribution (to be explored)*	*Glider Payload 2*
				Modular Seafloor Lander type A/B
	Population abundance of selected species – Marine Mammals (CI4 MM)	Abundance and density baseline information for marine mammals.	Cetacean abundance	Glider Payload 2
				Modular Seafloor Lander type A/B
Non-indigenous species (EO2)	Population and distribution of non-indigenous species (CI6)	Trends in abundance, temporal and spatial distribution and impacts of alien species.	Fauna abundance per unit area of the bed	Surface monitoring type A/B Port survey adapting the HELCOM/OSPAR protocol
			Alien species distribution	Machine learning tools
Harvest of commercially	Spawning stock biomass (CI7)	Spawning Stock Biomass reference points for most stocks.	Stock characteristics	Stock assessment at selected Observatories

Ecological Objective (EO)	Common Indicator (CI)	Knowledge gaps (identified in the 2017MED QSR)	ODYSSEA data and models	
			ODYSSEA's relevant data parameters	Sensor or modelling system(s)
exploited Fish and Shellfish (EO3)	Total landings (CI8)	Illegal, unregulated, or unreported fishing activities	Fishing behaviour publications	Twitter harvesting & semantic information fusion capabilities
Eutrophication (EO5)	Concentration of key nutrients in water column (CI13)	Key nutrients in the water column in coastal hotspots.	Concentration of key nutrients (nitrate, phosphate, etc.) in the water column	Delft3D-WAQ Water quality modelling system in all Observatories
				External sources (CMEMS model products)
			CDOM concentration in the water column	Glider payload 1
	Chlorophyll a concentration in the water column (CI14)	Chlorophyll *a* concentration in the water column.	Chlorophyll *a* pigment concentration in the water column	Glider payload 1
				Surface monitoring type A or B
				Modular Seafloor Lander type A/B
				Delft3D-WAQ Water quality modelling system in all Observatories
				External sources (CMEMS model and observation products, Sentinel 2A/2B and Sentinel 3A)
Hydrography (EO7)	Location and extent of habitats impacted directly by hydrographic alterations (CI15)	Extent of hydrographic alterations and its intersection with marine habitats.	Seagrass dynamics and distribution	Machine learning tools
		Hydrographic data with detailed temporal and spatial scale.	Hydrographic conditions (currents, waves, suspended sediment loads etc.)	Delft3D-FLOW Hydrodynamic modelling system in all Observatories
				Delft3D-WAQ-SPM suspended sediment modelling system in selected Observatories
Pollution (EO9)	Concentration of key harmful contaminants measured in the	Emerging contaminants, contaminants in deep-sea environments, and the dynamics of inputs, streams and distributions of contaminants.	Concentration of key harmful contaminants (e.g. heavy metals, etc.) in the water column	Delft3D-WAQ Water quality modelling system in all Observatories

Ecological Objective (EO)	Common Indicator (CI)	Knowledge gaps (identified in the 2017MED QSR)	ODYSSEA data and models	
			ODYSSEA's relevant data parameters	Sensor or modelling system(s)
	relevant matrix (CI17)		Identification of Harmful Algal Blooms	Remote sensing level 2 data using Sentinel 3
	Occurrence, origin and extent of acute pollution events and their impact on biota (CI19)	Illegal discharge from ships.	Oil spills accidentally discharged from ships and oil and gas platforms	Remote sensing level 2 data from Sentinel 2
			Extent, trajectory and concentration of oil spills	Delft3D-PART modelling system in selected Observatories
				OpenOil oil spill fate and transport modelling system for all Observatories
Marine litter (EO10)	Trends in the amount of litter washed ashore and/or deposited on coastlines (CI22)	Distribution, quantities and identification of marine litter sources for litter washed ashore or deposited on beaches and coasts at the basin scale.	Estimation of plastics/microplastics sources	OpenOil plastics/microplastics tracking modelling system in selected Observatories
			Beach litter distribution and abundance	Citizen science apps
	Trends in the amount of litter in the water column including microplastics and on the seafloor (CI23)	Distribution and quantities, identification, evaluation of accumulation areas, and detection of litter sources of litter in the water column, including microplastics and on the seafloor.	Litter abundance and type	Glider Payload 3
				Modular Seafloor Lander type B
				Surface monitoring type A/B
			Estimation of distribution of individual particles by following their tracks in time	Delft3D-PART Plastic dispersion modelling system in selected Observatories
			Estimation of plastic/microplastic distribution at the surface, in the water column, benthic	MEDSLIK-II plastics/microplastics tracking modelling system in selected Observatories

Ecological Objective (EO)	Common Indicator (CI)	Knowledge gaps (identified in the 2017MED QSR)	ODYSSEA data and models	
			ODYSSEA's relevant data parameters	Sensor or modelling system(s)
			sediments, and coasts.	
		Links between hydrodynamic factors to understand transport dynamics and accumulation zones.	Currents, sea level, water temperature, salinity and density	Delft3D-FLOW Hydrodynamic modelling system in all Observatories
			Plastic dispersion	Plastic dispersion forecasting system
Underwater noise (EO11)	Distribution of loud, low and mid-frequency impulsive sounds (CI26)	Data on underwater noise	Levels of underwater noise	Hydrophones deployed on mobile and static sensor systems at selected Observatories

Annex 2: Alignment between MSFD descriptors and ODYSSEA

ODYSSEA seeks to support monitoring implementation of the EU Marine Strategy Framework Directive (MSFD) within the Mediterranean Sea, as part of ODYSSEA's overall objective to support policy processes in the Mediterranean Sea region. Table A2 summarises how ODYSSEA's potential contributions align with the 11 MSFD descriptors that monitor 'good environmental status' (as described in European Commission decisions decision 2010/477/EU and decision 2017/848/EU).

Table A2: Summary of how ODYSSEA contributions align with MSFD Descriptors, and corresponding alignment with IMAP Ecological Objectives

MSFD Descriptors	Corresponding IMAP Ecological Objectives	Potential ODYSSEA contributions
D1 Biodiversity **Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions.**	EO1 Biodiversity is maintained or enhanced.	ODYSSEA is developing tools for fish and marine mammal species recognition and distribution. The data for these tools will be collected at the Observatories by static and mobile sensor systems equipped with cameras and hydrophones. It could be explored whether these tools could also provide data on the distributional range of marine turtles. The Glider Payload 2 and Modular Seafloor Lander type A/B will have acoustic recorders which will be used to obtain data on cetacean abundance. The Surface Monitoring type A/B sensor system will have cameras which will collect data on fauna abundance per unit area of the seabed in relatively shallow and transparent waters. The Species Distribution Model for eight pelagic fish species can be used to estimate abundance and diversity. For more information https://doi.org/10.3390/app10248900 Benthic seagrass species distribution obtained from UNEP-WCMC database were inter-related to oceanographic/habitat/environmental data from CMEMS and EMODnet. Machine Learning and neuro-fuzzy models were applied to explain seagrass species presence/absence and seagrass family preferences in environmental conditions. For more information https://doi.org/10.3390/w12102949, https://doi.org/10.1016/j.ecoinf.2018.09.004
D2 Non-indigenous species **Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems.**	EO2 Non-indigenous species do not adversely alter the ecosystem.	Static (seafloor and water column) sensor systems equipped with cameras with collect data on: • Fauna/flora abundance per unit area of seabed • Fish abundance in water bodies • Fish morphology, age and physiology • Habitat characterisation These are used to facilitate early detection and warning systems and estimate risk of transference. In addition, machine learning tools will be used to link alien species distribution and physical-chemical variability across the Mediterranean, to increase the understanding of alien species distribution.

MSFD Descriptors	Corresponding IMAP Ecological Objectives	Potential ODYSSEA contributions
D3 Commercial fish and shellfish **Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.**	EO3 Populations of commercially exploited fish and shellfish are within biologically safe limits.	Using the main ecosystem model (Ecopath with Ecosim) ODYSSEA has analyzed the trophic web at selected Observatories and devised a series of ecotrophic and catch-based indicators (e.g. catch trends, mean weighted trophic level of the catch (mTLc), Fishing in balance index (FiB)), for all pilot areas in the period 1970-2017. For more information https://doi.org/10.3390/w13040482. ODYSSEA is working on Twitter harvesting and semantic fusion tools to provide data on illegal, unregulated or unreported fishing activities. For more information https://ieeexplore.ieee.org/document/9190335.
D4 Food webs **All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.**	EO4 Alterations to component of marine food webs do not have long-term adverse effects.	At selected Observatories, ODYSSEA is applying the fishery model ECOPATH based on food web analysis (fish species abundance and diversity, reproduction, natural mortality and fisheries). The model will be coupled with hydrodynamic, wave and water quality models.
D5 Eutrophication **Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters.**	EO5 Human-induced eutrophication is prevented.	The Delft3D-WAQ water quality modelling system (at all Observatories) will provide regular water quality forecasts. Key nutrients that will be modelled include ammonia, nitrate, phosphate, adsorbed inorganic phosphorus, and silicate. This modelling system will be complemented by relevant data from external sources, including CMEMS. The Delft3D-WAQ water quality modelling system also calculates primary production and chlorophyll *a* concentration while integrating dynamic process modules for dissolved oxygen, nutrient availability and phytoplankton species. The model also includes a phytoplankton module (BLOOM) that simulates the growth, respiration and mortality of phytoplankton. In addition, the Glider Payload 1 sensor system (at selected Observatories) will measure CDOM concentration in the water column. Mobile and static sensor systems (at all Observatories) will collect data on chlorophyll *a* pigment concentration in the water column. External sources of relevant chlorophyll *a* data will be made available on the ODYSSEA Platform, including CMEMS data and satellite remote sensing observation products from Sentinel 2 and Sentinel 3.
D6 Sea floor integrity	EO6	*No relevant data or services were identified*

MSFD Descriptors	Corresponding IMAP Ecological Objectives	Potential ODYSSEA contributions
Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.	Sea Floor integrity is maintained	
D7 Hydrographical conditions **Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.**	E07 Alteration of hydrographic conditions does not adversely affect coastal and marine ecosystems.	The Delft3D-FLOW Hydrodynamic modelling system (at all Observatories) and the Delft3D-WAQ-SPM suspended sediment modelling system (at selected Observatories) will provide data on hydrographic conditions with high temporal and spatial resolution (currents, waves, sea level, water temperature, suspended sediment loads, salinity, density).
D8 Contaminants **Concentrations of contaminants are at levels not giving rise to pollution effects.**	*See D9*	At all Observatories, the Delft3D-WAQ water quality modelling system will model a wide range of substances, including concentrations of key harmful contaminants in the water column. For more information https://meetingorganizer.copernicus.org/EGU2018/EGU2018-5341.pdf At selected Observatories, satellite remote sensing level 2 data from Sentinel 3 will be used to provide information about Chlorophyll *a* and CDOM concentration, algal blooms indicators, phytoplankton taxa, etc. Modelling systems will model the extent, trajectory and concentration of oil spills. For more information https://ieeexplore.ieee.org/document/9190335 The Delft3D-PART modelling system (at selected Observatories) couples a particle-tracking module with a hydrodynamic 3D model to represent oil spills. The MEDSLIK-II oil spill fate and transport modelling system (at all Observatories) predicts the transport and weathering of oil spills. For more information https://meetingorganizer.copernicus.org/EGU2018/EGU2018-16401-4.pdf At selected Observatories, satellite remote sensing level 2 data from Sentinel 2 on oil spills accidentally discharged from ships will be collected.
D9 Contaminants in seafood **Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards.**	EO9 Contaminants cause no significant impact on coastal and marine ecosystems and human health.	*No relevant data or services were identified*

MSFD Descriptors	Corresponding IMAP Ecological Objectives	Potential ODYSSEA contributions
D10 Marine litter **Properties and quantities of marine litter do not cause harm to the coastal and marine environment.**	EO10 Marine and coastal litter does not adversely affect coastal and marine ecosystems.	Data on marine litter will be collected through citizen science mobile applications. Possible apps to draw on include Marine LitterWatch and an ODYSSEA app currently under development. The data can be used to analyse distribution, quantities and identification of marine litter types. Mobile and static sensor systems deployed at the Observatories will have microplastic sensors which will take real-time measurements of microplastic count and classification at different points in the water column. The Delft3D-PART modelling system (at selected Observatories where the microplastics sensors will be deployed) couples a particle-tracking module with a hydrodynamic 3D model to represent the transport of litter and estimate the dynamic, spatial concentration distribution of individual litter particles. The MEDSLIK-II plastics/microplastics tracking modelling system (at selected Observatories) will simulate plastic concentrations at the sea surface and fluxes onto the coastline and will be used to estimate the distribution of plastics/microplastics at the surface, in the water column, benthic sediments, and the coasts, and to identify accumulation zones. A Forecasting System will couple hydrodynamic and marine litter dispersion models (Delft3D-FLOW Hydrodynamic modelling system, Delft3D-PART Plastic dispersion modelling system) to produce hourly information about three-dimensional currents, sea level, water temperature, salinity and density at each grid cell.
D11 Energy supply, including underwater noise **Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.**	EO11 Noise from human activities cause no significant on marine and coastal ecosystems.	The mobile and static sensor systems deployed at selected Observatories will be equipped with hydrophones that can record underwater noise levels. These can provide data for the assessment of underwater noise and the threat/impact on cetacean distribution.

Annex 3: Alignment between ODYSSEA and Essential Ocean Variables

The Global Ocean Observing System (GOOS) has identified priority variables for monitoring life in the sea. The 'Essential Ocean Variables' (EOVs) have been identified with the intent of informing policy and management in the context of increasing human use of marine resources, coastal development and climate change, and were identified using three criteria: (i) relevance to GOOS themes of climate, operational ocean services such as weather forecasts and early warning systems, and ocean health; (ii) feasibility to observe or derive; and (iii) cost effectiveness of data collection and storage. Tables A3.1 and A3.2 give an overview of how current efforts under ODYSSEA are aligned with the EOVs, and for which MSFD Descriptors and IMAP Ecological Objectives these EOVs are relevant. Moving forward, this will allow identification of areas in which interoperability could be improved.

Table A3.1: Overview of datasets, data sources, models and algorithms under consideration or development for the Marinomica Platform and relevant Essential Ocean Variables

	In-situ measurements	**Coastal models**	**External Earth Observation datasets**	**Citizen Science**	**Algorithms**
DESCRIPTION	At the ODYSSEA Observatories new in-situ monitoring devices (fixed bottom and surface sensors, and gliders) are deployed measuring standard physical and biogeochemical variables, as well as novel measurements (e.g. microplastics, acoustic signal, etc.)	At the ODYSSEA Observatories high-resolution three-dimensional coastal models are setup to simulate hydrodynamics, wave conditions, water quality, oil spill (in selected observatories), jellyfish (in selected observatories), and ecosystem composition	Covering the entire Mediterranean Sea basin ODYSSEA collects and provides easy access to external databases containing in-situ measurements, satellite data, and model outputs	ODYSSEA collects and makes use (e.g. visualizes) of data provided by citizens through social media and dedicated citizen science apps	Using algorithms to merge, fuse, and transform the primary data products, ODYSSEA generates secondary variables that are not provided by any other data sources

	In-situ measurements	**Coastal models**	**External Earth Observation datasets**	**Citizen Science**	**Algorithms**
ESSENTIAL OCEAN VARIABLES (EOVS)	**Physics:** - Sea state - Sea surface height - Sea surface temperature - Subsurface temperature - Surface currents - Subsurface currents - Sea surface salinity - Subsurface salinity - Ocean surface heat flux **Biogeochemistry:** - Oxygen **Biology and Ecosystems:** - Phytoplankton biomass and diversity - Fish abundance and distribution - Marine turtles, birds, mammals abundance and distribution **Cross-disciplinary:** - Ocean colour - Ocean sound	**Physics:** - Sea state - Ocean surface stress - Sea surface height - Sea surface temperature - Subsurface temperature - Surface currents - Subsurface currents - Sea surface salinity - Subsurface salinity - Ocean surface heat flux **Biogeochemistry:** - Oxygen - Nutrients - Inorganic carbon - Dissolved organic carbon **Biology and Ecosystems:** - Phytoplankton biomass and diversity - Fish abundance and distribution	**Physics:** - Sea state - Ocean surface stress - Sea surface height - Sea surface temperature - Subsurface temperature - Surface currents - Subsurface currents - Sea surface salinity - Subsurface salinity - Ocean surface heat flux **Biogeochemistry:** - Oxygen - Nutrients **Biology and Ecosystems:** - Phytoplankton biomass and diversity **Cross-disciplinary:** - Ocean colour	**EOVs:** None **Non-EOVs:** - Jellyfish, invasive species - Pollution sources	**Physics:** - Sea state **Biogeochemistry:** - Oxygen - Nutrients **Biology and Ecosystems:** - Phytoplankton biomass and diversity
OBSERVING/MODELLING PLATFORM	- **Develogic Modular Surface Sensor** (fluorometer + hydrophone + submerged camera + microplastics sensor) - **Develogic Deep Water Sea Lander** - **Alseamar SeaExplorer glider:** • Payload 1: GPS, CTD, DO, Phyto, CDOM, Turbidity, • Payload 2: Passive Acoustic Monitoring (hydrophone), • Payload 3: CTD and microplastics	- **Hydrodynamic model**: Delft3D-FLOW, MOHID - **Wave model**: Delft3D-WAVE, SWAN - **Biogeochemical model**: Delft3D-WAQ, MOHID - **Oil spill model**: MEDSLIK-II - **Mussel farm model** - **Ecosystem model:** ECOPATH - **Jellyfish model:** Delft3D-PART, OpenDrift	- CMEMS - GEOSS - EMODnet - NOAA - ECMWF - GOOS - MonGOOS - SeaDataNet - UNEP-WCMC	- Twitter - Marine LitterWatch App - Pangaea	- Algorithm for Eutrophication Index in sea water - Algorithm for TRophic IndeX in sea water - Algorithm for UNscaled TRophic IndeX in sea water - Algorithm for Efficiency Coefficient in sea water - Algorithm for wave power

Table A3.2: Overview of current alignment of ODYSSEA efforts with Essential Ocean Variables (EOVs), and relevant MSFD Descriptors (D) and IMAP Ecological Objectives (EO)

Essential Ocean Variables (EOVs)	ODYSSEA data services	ODYSSEA sensor systems and models	MSFD Descriptors (D)/IMAP Ecological Objectives (EO)
Physics			
Sea state	Wave power	In-situ sensors Delft3D-FLOW hydrodynamic model Delft3D-WAVE wave model	D7/EO7 Hydrographical conditions
Ocean surface stress	N/A		
Sea ice	N/A	N/A	
Sea surface height	Sea surface height	In-situ sensors Delft3D-FLOW hydrodynamic model Remote sensing (L3 & L4)	
Sea surface temperature	Sea surface temperature		
Subsurface temperature	Water temperature		
Surface currents	Currents		
Subsurface currents			
Sea surface salinity	Salinity concentrations in the water column		
Subsurface salinity			
Ocean surface heat flux	N/A		
Biogeochemistry			
Oxygen	Dissolved oxygen concentration	In-situ sensors Delft3D-WAQ water quality model	N/A
Nutrients	Key nutrient concentration		D5/EO5 Eutrophication
Inorganic carbon	Concentrations of inorganic carbon in the water column		N/A
Transient tracers	N/A		D8/D9/EO9 Contaminants
Nitrous oxide	N/A		N/A
Stable carbon isotopes	N/A		N/A
Dissolved organic carbon	Concentrations of dissolved organic carbon in the water column		N/A

Essential Ocean Variables (EOVs)	ODYSSEA data services	ODYSSEA sensor systems and models	MSFD Descriptors (D)/IMAP Ecological Objectives (EO)
Particulate matter	Concentrations in the water column		D8/D9/EO9 Contaminants
Biology and Ecosystems			
Phytoplankton biomass and diversity	Chlorophyll *a* concentration Harmful algal blooms early warning	In-situ sensors Remote sensing (L3 & L4 from multi satellite and Sentinel-3 OLCI observations) Delft3D-WAQ water quality model	D1/EO1 Biodiversity D5/EO5 Eutrophication
Zooplankton biomass and diversity	N/A	In-situ sensors	D1/EO1 Biodiversity
Fish abundance and distribution	Suitability maps Location of nursery areas	In-situ sensors ECOPATH ecosystem model	D1/EO1 Biodiversity D4/EO4 Food webs
Marine turtles, birds, mammals abundance and distribution	Marine mammal distribution and abundance	In-situ acoustic sensors	D1/EO1 Biodiversity
Hard coral cover and composition	N/A	N/A	
Seagrass cover and composition	Seagrass suitability map	Machine learning tools	
Macroalgal canopy cover and composition	N/A	N/A	
Mangrove cover and composition	N/A	N/A	
Microbe biomass and diversity (*emerging)	N/A	N/A	
Invertebrate abundance and distribution (*emerging)	N/A	N/A	
Cross-disciplinary			
Ocean colour	Chlorophyll *a* concentration, turbidity	Remote sensing (L3 & L4 from multi satellite and Sentinel-3 OLCI observations)	D5/EO5 Eutrophication
Ocean sound	Acoustic signal	In-situ sensor systems	D11/EO11 Underwater noise