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Agenda item 4: Guidance on monitoring concerning the biodiversity and non-indigenous species common indicators

Supporting the UNEP/MAP Integrated Monitoring and Assessment Programme (IMAP): ODYSSEA alignment to current IMAP knowledge gaps identified from the Mediterranean 2017 Quality Status Report

UNEP/MAP
SPA/RAC - Tunis, 2019

ODYSSEA

Operating a network of integrated observatory systems
in the Mediterranean Sea

POLICY USE CASE:

Supporting the UNEP/MAP Integrated Monitoring and Assessment Programme (IMAP)

ODYSSEA alignment to current IMAP knowledge gaps identified from the Mediterranean 2017 Quality Status Report

Working document

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(Work Package 9 'End-user and policy makers' involvement')

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Executive Summary

The Integrated Monitoring and Assessment Programme (IMAP) of the UN Environment Mediterranean Action Plan (UNEP/MAP) sets out monitoring and reporting requirements for 11 Ecological Objectives (EOs) and 27 Common Indicators to achieve Good Environmental Status. In 2017, UNEP/MAP published the first Mediterranean Quality Status Report (MED QSR 2017) based on the IMAP objectives and indicators. The 2017 Mediterranean Quality Status Report provides a detailed assessment of the status of marine and coastal ecosystems in the Mediterranean. The report also determines the availability of information needed for assessing the IMAP Common Indicators, identifying current knowledge gaps.

The European Union Horizon 2020 project ODYSSEA is establishing an interoperable, user-driven platform that integrates data from a network of existing observing and forecasting systems and new *in situ* monitoring Observatories across the Mediterranean Sea. The ODYSSEA Platform aims to support decision-making for a sustainable blue economy and effective conservation of marine ecosystems and biodiversity by facilitating access to data and tailored information services. One particular objective of ODYSSEA is to support policy processes in the Mediterranean Sea region, such as IMAP.

This document presents an analysis of the key knowledge gaps identified in the 2017 Mediterranean Quality Status Report and how these align with the data and information services that are in development for the ODYSSEA Platform. The 'gap analysis' suggests that ODYSSEA data and information services 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. A set of priority areas for collaboration between ODYSSEA and IMAP are identified, with particular focus on monitoring of marine mammals (abundance, distribution – EO1) and marine litter (beach litter, microplastics – EO10), but also eutrophication (nutrients, Chlorophyll *a* – EO5), pollution (harmful contaminants, oil spills – EO9; underwater noise – EO11) and hydrographic conditions (EO7).

To support the IMAP process through the ODYSSEA Platform, a two-step approach for the alignment between IMAP and ODYSSEA is proposed. In the medium-term, ODYSSEA data and services could contribute to the preparation of the next Mediterranean Quality Status Report in 2023 (MED QSR 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 efforts under IMAP.

Contents

1 Introduction

1.1 Integrated monitoring and assessment programme in the Mediterranean Sea

In 2016, the Contracting Parties to the UN Environment Mediterranean Action Plan (UNEP/MAP) for the Barcelona Convention adopted the Integrated Monitoring and Assessment Programme (IMAP) (decision IG. 22/7) to support the implementation of the Ecosystem Approach in the Mediterranean. The IMAP sets out monitoring and reporting requirements for 11 Ecological Objectives and 27 Common Indicators to achieve Good Environmental Status. In the first phase of IMAP implementation (2016-2019), the Contracting Parties are currently reviewing their existing national monitoring programmes and updating these to align with IMAP requirements. Following the establishment of national integrated monitoring programmes, the Contracting Parties will report quality assured data on the state of the environment into an integrated IMAP Information System. The Common Indicators and national monitoring data inform regional IMAP assessments, produced by the UNEP/MAP Secretariat.

In 2017, UNEP/MAP published the first Mediterranean Quality Status Report based on the Ecological Objectives and Common Indicators of IMAP. As the Contracting Parties are still in the process of updating their national monitoring programmes, the 2017 Mediterranean Quality Status Report (2017 MED QSR) includes available data from a number of different sources, such as (i) monitoring programmes of the Programme for the Assessment and Control of Marine Pollution in the Mediterranean Region (MED POL), (ii) monitoring programmes for biodiversity and non-indigenous species supported by Specially Protected Areas Regional Activity Centre (UN Environment/MAP – SPA/RAC, in close collaboration with regional partners, in particular the General Fisheries Commission for the Mediterranean (GFCM) and the Secretariat of the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic area (ACCOBAMS)), as well as (iii) national reports and regional policies, programmes and projects. The 2017 MED QSR provides a detailed assessment of the status of marine and coastal ecosystems in the Mediterranean. The report also determines the availability of information needed for assessing the IMAP Common Indicators, identifying current knowledge gaps.

1.2 Addressing IMAP knowledge gaps through ODYSSEA

The European Union Horizon 2020 project ODYSSEA ('Operating a network of integrated observatory systems in the Mediterranean Sea')[1] is establishing an interoperable, user-driven platform that integrates data from various networks of observing and forecasting systems across the Mediterranean Sea. Besides drawing from existing ocean observation data, the project is setting up nine *in situ* monitoring Observatories in data-poor regions. The ODYSSEA Platform aims to support decision-making for a sustainable blue economy and effective conservation of marine ecosystems and biodiversity in the Mediterranean Sea by facilitating access to data and tailored information services. The potential end-users of the ODYSSEA Platform include decision-makers from the public sector, industry and conservation, as well as members of the public, education and research institutions. One particular objective of ODYSSEA is to support policy processes in the Mediterranean Sea region, such as IMAP.

To understand how the ODYSSEA Platform could support the implementation of IMAP, this document reviews the potential for using data and information services that are being collated and developed under ODYSSEA to contribute to the assessment of the IMAP Common Indicators.

[1] More information available at: http://odysseaplatform.eu/.

1.1 About this document

A ‘gap analysis’ was conducted, summarising the key knowledge gaps identified in the 2017 Mediterranean Quality Status Report and aligning these with the data and information services that are in development, or could be provided through, the ODYSSEA Platform. The following chapters present the results of this ‘gap analysis’, including:

1) A brief overview of ODYSSEA Observatories;
2) A summary table of current IMAP knowledge gaps and relevant ODYSSEA data or information services;
3) A detailed analysis of current IMAP knowledge gaps and relevant ODYSSEA data or information services by Ecological Objective and Common Indicator; and
4) Proposed next steps.

2 The ODYSSEA Observatories

Observatory areas

ODYSSEA will establish, operate and maintain nine pilot Observatories around the Mediterranean Sea. Four Observatories will cover the North African countries (except Libya), three Observatories will cover the Eastern Mediterranean (Aegean and Levantine Sea), one the Northern Adriatic Sea and the last one the Valencia coastline.

ODYSSEA sensor systems

A range of mobile and static sensor systems will be deployed at the ODYSSEA Observatories. These systems will be equipped with different sensors to collect near-real time measurements on a range of parameters to fill existing data gaps and increase the temporal and spatial resolution of observational and forecasting data in the Mediterranean Sea (Table 2).

Table 1: ODYSSEA sensor systems and the data they provide

System	Sensor	Data
Glider Payload 1	GPCTD + DO	Conductivity, Temperature, Dissolved Oxygen
	FLBBCD	Chlorophyll A Fluorescence (proxies of phytoplankton abundance), Backscattering (total particle concentration), CDOM Fluorescence (dissolved organic matter)
Glider Payload 2	Acoustic sensor	Passive acoustic monitoring
Glider payload 3	CTD + Microplastic	Microplastic count and classification
MSL 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
MSL 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 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
Surface monitoring type C x5	Aanderaa 4531	Cyclops 7F
	Aanderaa 4319B	Conductivity, Temperature
	Cyclops 7F	Chlorophyll A Fluorescence

ODYSSEA modelling systems

The observatories will also run high-resolution operational models (Table 3). The main modelling interfaces used by the ODYSSEA Project are the Delft-FEWS and the Aquasafe systems; these are the tools used to interlink models, import initial and boundary conditions, execute the model chain and visualize results on the ODYSSEA Platform.

Table 2: ODYSSEA modelling systems

Model	Brief summary
The Delft3D-FLOW Model	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.
The Delft3D-WAVES Model	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.
The DELWAQ Model	This model combines components from Delft3D-FLOW and the biogeochemical model, 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.
The MEDSLIK-II Model	MEDSLIK-II is a Lagrangian marine surface oil spill model designed to simulate oil slick transport and transformation processes for realistic oceanic cases.
The ECOPATH Model	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.
The Mussel Farm Population Dynamics Model	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.

3 Summary table: IMAP knowledge gaps and ODYSSEA data/services

Table 4 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 services. 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 3: Summary of IMAP knowledge gaps and ODYSSEA data/services

Ecological Objective (EO)	Common Indicator (CI)	Knowledge gaps (identified in the 2017MED QSR)	ODYSSEA data and services	
			ODYSSEA's relevant data parameters	Sensor or modelling system(s) collecting/producing the data parameter
Biodiversity and Ecosystems (EO1)	Habitat distributional range and condition of the habitat's typical species and communities (CI1 & CI2)	Role of resting stage banks for plankton dynamics.	*n/a*	
		Impact of gelatinous macrozooplankton on the functioning of ecosystems.	*n/a*	
		Links between deep sea systems and coastal ones.	*n/a*	
		Habitat identification for the pelagic habitats and mapping processes.	*n/a*	
		Knowledge of connectivity processes.	*n/a*	
		Development of innovative techniques such as remote sensing and acoustic for the study of seabed to cover large areas at high resolution.	*n/a*	
	Species distributional range – Marine Mammals (CI3 MM)	Marine mammal species distribution ranges, particularly for southern Mediterranean countries to consolidate baseline information.	Marine mammal species recognition and distribution	Glider Payload 2 Modular Seafloor Lander type A/B
	Species distributional range – Seabirds (CI3 MS)	Information on seabird species distributional ranges.	*n/a*	
	Species distributional range – Marine Reptiles (CI3 MR)	Marine turtles species distribution ranges, particularly location of all breeding, nesting, wintering, feeding and developmental sites, connectivity among these sites,	*Potentially marine turtle distribution (to be explored)*	*Glider Payload 2* *Modular Seafloor Lander type A/B*

		vulnerability/resilience of these sites, and assimilation of research into a single database.		
	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
	Population abundance of selected species – Seabirds (CI4 MS)	Population abundance of seabirds.	*n/a*	
	Population abundance of selected species – Marine Reptiles (CI4 MR)	Marine turtle population abundance, particularly the numbers frequenting breeding, foraging and wintering sites, and the vulnerability/resilience of populations.	*n/a*	
	Population demographic characteristics – Marine Mammals (CI5 MM)	Time-series data of Marine Mammal population demographics.	*n/a*	
	Population demographic characteristics – Seabirds (CI5 MS)	Seabird demographic parameters.	*n/a*	
	Population demographic characteristics – Marine Reptiles (CI5 MR)	Marine Reptile population demographics; particularly sex ratios, recruitment, mortality, health and vulnerability/ resilience in relation to physical pressures.	*n/a*	
Non-indigenous species (EO2)	Trends in abundance, temporal occurrence, and spatial distribution of non-indigenous species, particularly invasive, non-indigenous species, notably in risk areas, in relation to the main vectors and pathways of spreading of such species (CI6)	Trends in abundance, spatial distribution and impacts of alien species.	Fauna abundance per unit area of the bed	Surface monitoring type A/B
			Alien species distribution	Machine learning tools
Harvest of commercially	Spawning stock Biomass (CI7)	Maximum Sustainable Yield based Spawning Stock Biomass reference points for most stocks.	Stock characteristics	Stock assessment at selected Observatories

exploited Fish and Shellfish (EO3)	Total landings (CI8)	Illegal, unregulated, or unreported fishing activities to correctly estimate total landings.	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 the 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 relevant matrix (CI17)	Concentrations of key harmful contaminants in the relevant matrix, particularly 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
			Identification of Harmful Algal Blooms	Remote sensing level 2 data using Sentinel 3
	Level of pollution effects of key harmful contaminants measured in the relevant matrix (CI18)	Level of pollution effects of key contaminants.	*n/a*	

	Occurrence, origin (where possible), extent of acute pollution events (e.g. slicks from oil, oil products and hazardous substances), and their impact on biota affected by this pollution (CI19)	Illegal discharge from ships.	Oil spills accidentally discharged from ships	Remote sensing level 2 data from Sentinel 2
			Extent, trajectory and concentration of oil spills	Delft3D-PART modelling system in selected Observatories
				MEDSLIK-II oil spill fate and transport modelling system for all Observatories
		Effect of pollution events caused by shipping on biota.	*n/a*	
	Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels in commonly consumed seafood (CI20)	Actual levels of contaminants in commonly consumed seafood on a regional scale.	*n/a*	
	Percentage of intestinal enterococci concentration measurements within established standards (CI21)	Microbial pollution to measure percentage of intestinal enterococci concentration measurements.		
Marine litter (EO10)	Trends in the amount of litter washed ashore and/or deposited on coastlines (including analysis of its composition, spatial distribution and, where possible, source) (CI22)	Distribution, quantities and identification of marine litter sources for litter washed ashore or deposited on coastlines, found on the beach, and on shorelines and coasts at the basin scale.	Estimation of plastics/microplastics sources	MEDSLIK-II 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
			Estimates of dynamic, spatial concentration 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 sediments, and the coasts.	MEDSLIK-II plastics/microplastics tracking modelling system in selected Observatories
	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

4 IMAP gap analysis and alignment with ODYSSEA

4.1 Biodiversity and ecosystems (EO1)

Ecological Objective 1: Biological diversity is maintained or enhanced. The quality and occurrence of coastal and marine habitats and the distribution and abundance of coastal and marine species are in line with prevailing physiographic, hydrographic, geographic and climatic conditions.

Common Indicator 1: Habitat distributional range & Common Indicator 2: Condition of the habitat's typical species and communities

(Link to 2017 Quality Status Report: CI1 & CI2)

Knowledge gap: Specific habitat distributional ranges and conditions of the habitat's typical species and communities require further research, including the following:

- Role of resting stage banks for plankton dynamics;
- Impact of gelatinous macrozooplancton on the functioning of ecosystems;
- Links between deep sea systems and coastal ones;
- Habitat identification for the pelagic habitats and mapping processes;
- Knowledge of connectivity processes;
- Development of innovative techniques such as remote sensing and acoustic for the study of seabed to cover large areas at high resolution.

Potential ODYSSEA contribution: *No relevant data or services identified*

Common Indicator 3: Species distributional range – Marine Mammals

(Link to 2017 Quality Status Report: CI3 MM)

Knowledge gap: Great disparity in research effort to assess marine mammal species distribution ranges, with efforts particularly needed in southern Mediterranean countries to consolidate baseline information and eventually obtain long time series of data.

Potential ODYSSEA contribution: The ODYSSEA Project is developing tools for fish and marine mammal species recognition and distribution. Once developed, this will use the cameras and hydrophones on Glider Payload 2 and Modular Seafloor Lander type A/B to collect data.

Common Indicator 3: Species distributional range – Seabirds

(Link to 2017 Quality Status Report: CI3 MS)

Knowledge gap: Information on seabird species distributional ranges is patchy and often lacking.

Potential ODYSSEA contribution: *No relevant data or services identified*

Common Indicator 3: Species distributional range – Marine Reptiles

(Link to 2017 Quality Status Report: CI3 MR)

Knowledge gap: Assimilation of all information on the distribution of marine turtles at breeding, foraging, developmental and wintering grounds is needed, particularly to understand the connectivity of these sites and their vulnerability/resilience to physical pressures when considering different size classes, populations and species.

Potential ODYSSEA contribution: The ODYSSEA Project is developing tools for fish and marine mammal species recognition and distribution. Once developed, this will use the cameras and hydrophones on Glider Payload 2 and Modular Seafloor Lander type A/B to collect data. It could be explored whether these tools could also provide data on the distributional range of marine turtles.

Common Indicator 4: Population abundance of selected species – Marine Mammals

(Link to 2017 Quality Status Report: CI4 MM)

Knowledge gap: Baseline information on the abundance and density for many species of cetaceans is patchy throughout the Mediterranean Sea, with estimates at the regional scale unavailable.

Potential ODYSSEA contribution: Systems deployed at ODYSSEA Observatories (Glider Payload 2 and Modular Seafloor Lander type A/B) will have **acoustic recorder** sensors, which will be used to obtain data on cetacean abundance. The acoustic recorders will simultaneously acquire and store acoustic signal, with the characteristics of the sensor systems allowing the sensors to collect data from different points in the water column:

- The gliders have several navigation modes:
    - Surveying – glider goes up and down in a forward projection
    - Virtual mooring – glider stays static at one point
    - Seabed anchored – glider dives, lands on the seabed floor and inflects up
    - Drift – on the surface or at an impression depth
- The Modular Seafloor Lander is an autonomous system which will be lowered to the bottom of the sea to collect information on the seafloor.

Common Indicator 4: Population abundance of selected species – Seabirds

(Link to 2017 Quality Status Report: CI4 MS)

Knowledge gap: Information on population abundance of seabirds is patchy, often old and subject to potentially high biases, particularly in the case of the shearwaters. In particular, information on seabird breeding population is patchy or missing completely for many eastern and southern countries, as well some Adriatic countries.

Potential ODYSSEA contribution: *No relevant data or services identified*

Common Indicator 4: Population abundance of selected species – Marine Reptiles

(Link to 2017 Quality Status Report: CI4 MR)

Knowledge gap: Major gaps exist in estimating the population abundance of marine turtles, including seasonal and total numbers of adult males frequenting breeding sites, numbers of adult males and females frequenting foraging and wintering sites, and vulnerability/resilience of populations and subpopulations in relation to physical and anthropogenic pressures. Assimilation of all research materials into a single database is needed.

Potential ODYSSEA contribution: The Surface Monitoring type A/B sensor system, deployed at ODYSSEA Observatories, will have cameras which will collect data on fauna abundance per unit area of the seabed. These surface systems are deployed at relatively shallow and transparent waters and will be able to monitor on flora/fauna abundance on the seabed.

Common Indicator 5: Population demographic characteristics – Marine Mammals

(Link to 2017 Quality Status Report: CI5 MM)

Knowledge gap: Systematic monitoring programmes are needed to collect time series data on marine mammal population demographic characteristics, to allow the assessment of trends over time and space.

Potential ODYSSEA contribution: *No relevant data or services identified*

Common Indicator 5: Population demographic characteristics – Seabirds

(Link to 2017 Quality Status Report: CI5 MS)

Knowledge gap: Information on seabird demographic parameters is extremely scarce in the Mediterranean region, except for Audouin's gull.

Potential ODYSSEA contribution: *No relevant data or services identified*

Common Indicator 5: Population demographic characteristics – Marine Reptiles

(Link to 2017 Quality Status Report: CI5 MR)

Knowledge gap: Information on marine turtle population demographics is patchy. Better information is needed with particular focus on 1) sex ratios within different age classes and habitat components (breeding, foraging, wintering, developmental habitats), and overall within and across populations, 2) recruitment and mortality in different components of the populations, 3) physical and genetic status of these groups, and 4) vulnerability/resilience of these groups to physical pressures.

Potential ODYSSEA contribution: *No relevant data or services identified*

4.2 Non-indigenous species (EO2)

Ecological Objective 2: Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem.

Common Indicator 6: Trends in abundance, temporal occurrence, and spatial distribution of non-indigenous species, particularly invasive, non-indigenous species, notably in risk areas, in relation to the main vectors and pathways of spreading of such species

(Link to 2017 Quality Status Report: CI6)

Knowledge gap: The assessment of trends in abundance, spatial distribution and impacts of alien species is largely lacking.

Potential ODYSSEA contribution: **Camera and lights** on sensor systems (Surface Monitoring type A x1 and Surface Monitoring type B x1) will collect the following data parameters:

- Fauna/flora abundance per unit area of the bed
- Fish abundance in water bodies
- Fish morphology age and physiology
- Habitat characterisation

In addition, machine learning tools will be used to link alien species distribution and physical-chemical variability across the Mediterranean. This will be used to increase the understanding of alien species distribution.

4.3 Harvest of commercially exploited fish and shellfish (EO3)

Ecological Objective 3: Populations of selected commercially exploited fish and shellfish are within biologically safe limits, exhibiting a population age and size distribution that is indicative of a healthy stock.

Common Indicator 7: Spawning stock biomass

(Link to 2017 Quality Status Report: CI7)

Knowledge gap: Maximum Sustainable Yield based Spawning Stock Biomass reference points (or proxy) do not exist for most stocks.

Potential ODYSSEA contribution: Stock assessments will be undertaken at selected ODYSSEA Observatories.

Common Indicator 8: Total landings

(Link to 2017 Quality Status Report: CI8)

Knowledge gap: Data is needed on illegal, unregulated, or unreported fishing activities to correctly estimate total landings.

Potential ODYSSEA contribution: The ODYSSEA Platform will include data on **illegal, unregulated, or unreported fishing activities**, which will be collected through Twitter harvesting and sematic fusion tools/applications. Twitter harvesting tools use twitter open source information, with a possible option to integrate other open data sources. To produce data on illegal, unregulated, or unreported fishing activities, the ODYSSEA twitter harvesting tool will focus on fishing vessel behaviour and related publications.

In addition, the Platform will incorporate data from the FAO/GFCM databases.

Common Indicator 9: Fishing mortality

(Link to 2017 Quality Status Report: CI9)

Knowledge gap: The level of information on fishing mortality differs between geographic areas. Information on fishing capacity, which is needed to correctly estimate fishing capacity, is incomplete or inaccurate.

Potential ODYSSEA contribution: *No relevant data or services identified*

4.4 Eutrophication (EO5)

Ecological Objective 5: Human-induced eutrophication is prevented, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters.

Common Indicator 13: Concentrations of key nutrients in water column

(Link to 2017 Quality Status Report: CI13)

Knowledge gap: A more comprehensive dataset of key nutrients in the water column is required in coastal hotspots to accurately assess trends for nutrients.

Potential ODYSSEA contribution: The **Delft3D-WAQ water quality modelling system** will be implemented at all ODYSSEA Observatories. The model allows great flexibility in the substances to be modelled, as well as a wide range of physical, (bio)chemical and biological process to be considered. This will provide regular water quality forecasts in support of integral water management. Key nutrients that will be modelled include ammonia, nitrate, phosphate, adsorbed inorganic phosphorus, and silicate. This modelling system will also be complemented by relevant data from external sources, including CMEMS model products providing nutrient concentrations.

In addition, the Glider Payload 1 sensor systems, deployed at ODYSSEA Observatories, will measure **CDOM concentration** in the water column.

Common Indicator 14: Chlorophyll-a concentration in water column

(Link to 2017 Quality Status Report: CI14)

Knowledge gap: Data availability for chlorophyll *a* concentration in the water column needs to be improved, to capture biomass changes in coastal waters using long time series.

(For potential ODYSSEA contribution, see next page.)

Potential ODYSSEA contribution: The Glider Payload 1, Modular Seafloor Lander type A/ B, and Surface Monitoring type A/B/C sensor systems, deployed at ODYSSEA Observatories, will have **chlorophyll *a* sensors**. Theses sensors will collect data on chlorophyll pigment concentration in the water column, a proxy of phytoplankton abundance. The characteristics of the sensor systems allow the sensors to collect data from different points in the water column:

- The gliders have several navigation modes:
  - Surveying – glider goes up and down in a forward projection
  - Virtual mooring – glider stays static at one point
  - Seabed anchored – glider dives, lands on the seabed floor and inflects up
  - Drift – on the surface or at an impression depth
- The Modular Seafloor Lander is an autonomous system which will be lowered to the bottom of the sea to collect information on the seafloor.
- The surface monitoring systems will be mounted to certain structures (fish farm nets, mussel farms, oil platforms, etc.).

The **Delft3D-WAQ water quality modelling system**, implemented at all ODYSSEA Observatories, 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.

External sources of relevant chlorophyll *a* data will also be made available on the ODYSSEA Platform, including the CMEMS model and satellite remote sensing observation products from Sentinel 2A/2B and Sentinel 3A.

4.5 Hydrography (EO7)

Ecological Objective 7: Populations of selected commercially Alteration of hydrographic conditions does not adversely affect coastal and marine ecosystems.

Common Indicator 15: Location and extent of habitats impacted directly by hydrographic alterations

(Link to 2017 Quality Status Report: CI15)

Knowledge gap: There are insufficient surveys and monitoring of this indicator throughout the Mediterranean Sea, with a lack of sound assessment methodologies. In particular, assessments which estimate the extent of hydrographic alterations (knowing conditions before and after construction) and its intersection with marine habitats are currently rare in the Mediterranean.

Potential ODYSSEA contribution: Machine learning tools will be used to link seagrass species distribution and physical-chemical variability across the Mediterranean. This will be used to increase the understanding of seagrass dynamics and distribution.

Knowledge gap: Lack of hydrographic data with detailed temporal and spatial scale.

Potential ODYSSEA contribution: In order to provide hydrographic data with detailed temporal and spatial scale, the following modelling systems will be set up:

- The **Delft3D-FLOW Hydrodynamic modelling system** in all Observatories
- The **Delft3D-WAQ-SPM suspended sediment modelling system** in selected Observatories

These modelling systems will provide data on hydrographic conditions at high temporal and spatial resolution, including currents, waves, sea level, water temperature, suspended sediment loads, salinity and density.

4.6 Pollution (EO9)

Ecological Objective 9: Contaminants cause no significant impact on coastal and marine ecosystems and human health.

Common Indicator 17: Concentration of key harmful contaminants measured in the relevant matrix

(Link to 2017 Quality Status Report: CI17)

Knowledge gap: There is limited spatial coverage, temporal consistency and quality assurance of concentrations of key harmful contaminants in the relevant matrix. In particular, data needs to be improved for emerging contaminants, the level of contaminants in deep-sea environments, and the dynamics of inputs, streams and distributions of contaminants.

Potential ODYSSEA contribution: The **Delft3D-WAQ water quality modelling system**, implemented at all ODYSSEA Observatories, will model a wide range of substances. This will include modelling the concentration of key harmful contaminants, such as heavy metals, in the water column.

At particular Observatories, satellite remote sensing level 2 data from Sentinel 3 will be able to provide identification of Harmful Algal Blooms. Level 2 data is high-resolution corrected data which allow near real time delivery. This data can be used to provide a timely service in terms of Chlorophyll *a* and CDOM concentration, algal blooms indicators, identifying phytoplankton taxa, etc.

Common Indicator 18: Level of pollution effects of key contaminants measured in the relevant matrix

(Link to 2017 Quality Status Report: CI18)

Knowledge gap: Developments are needed to measure level of pollution effects of key contaminants, which should include: confirmation of the added value of batteries of biomarkers in long-term marine monitoring as ‘early warning’ systems, test of new research-proved tools such as ‘omics’, analytical quality harmonization, development of suites of assessment criteria for the integrated chemical and biological assessment methods, and review of the scope of the biological effects monitoring programmes.

Potential ODYSSEA contribution: *No relevant data or services identified*

Common Indicator 19: Occurrence, origin (where possible), extent of acute pollution events (e.g. slicks from oil, oil products and hazardous substances), and their impact on biota affected by this pollution

(Link to 2017 Quality Status Report: CI19)

Knowledge gap: There is very little data available regarding illegal discharge from ships (c.f. acute pollution events).

Potential ODYSSEA contribution: Modelling systems, implemented at some of the ODYSSEA Observatories, will model the extent, trajectory and concentration of oil spills.

- The **Delft3D-PART modelling system** will be implemented in selected Observatories. This couples a particle-tracking module with the hydrodynamic 3D model to represent oil spill.
- The **MEDSLIK-II oil spill fate and transport modelling system** will be implemented for all Observatories. This is used to predict the transport and weathering of an oil spill.

At particular Observatories, satellite remote sensing level 2 data on oil spills accidentally discharged from ships will be collected by Sentinel 2. Level 2 data is high-resolution corrected data which allow near real time delivery.

Knowledge gap: There is little information on the effect of pollution events caused by shipping on biota.

Potential ODYSSEA contribution: *No relevant data or services identified*

Common Indicator 20: Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels in commonly consumed seafood

(Link to 2017 Quality Status Report: CI20)

Knowledge gap: There is a lack of regularly updated information on actual levels of contaminants in commonly consumed seafood on a regional scale.

Potential ODYSSEA contribution: *No relevant data or services identified*

Common Indicator 21: Percentage of intestinal enterococci concentration measurements within established standards

(Link to 2017 Quality Status Report: CI21)

Knowledge gap: There is a lack of recent datasets on microbial pollution to measure percentage of intestinal enterococci concentration measurements within established standards.

Potential ODYSSEA contribution: *No relevant data or services identified*

4.7 Marine litter (EO10)

Ecological Objective 10: Marine and coastal litter do not adversely affect coastal and marine environment.

Common Indicator 22: Trends in the amount of litter washed ashore and/or deposited on coastlines (including analysis of its composition, spatial distribution and, where possible, source)

(Link to 2017 Quality Status Report: CI22)

Knowledge gap: Inconsistent data on distribution, quantities and identification of marine litter sources for litter washed ashore or deposited on coastlines, found on the beach, and on shorelines and coasts at the basin scale.

Potential ODYSSEA contribution: Data from the **Marine LitterWatch mobile app** will be collated into the ODYSSEA Platform. This app utilises citizen engagement to collect and share comparable data on marine litter on beaches. Communities organize either clean-up or monitoring events on beaches and use surveys on the mobile app to report on litter items found. The data can then be used to analyse distribution, quantities and identification of marine litter found on the beach.

The **MEDSLIK-II plastics/microplastics tracking modelling system** will be implemented in selected Observatories. This will simulate the plastic concentrations at the sea surface and fluxes onto the coastline that originated from terrestrial and maritime inputs. As a result, the modelling system will provide estimations of plastic sources, including for microplastics.

Common Indicator 23: Trends in the amount of litter in the water column including microplastics and on the seafloor

(Link to 2017 Quality Status Report: CI23)

Knowledge gap: More valuable and comparable data is needed on **litter and microplastics in the water column, and on the seafloor, including** 1) distribution and quantities, 2) identification (size, type, possible impact), 3) evaluation of accumulation areas (closed bays, gyres, canyons, and specific deep-sea zones), and 4) detection of litter sources (rivers, diffuse inputs)**.**

(For potential ODYSSEA contribution, see next page.)

Potential ODYSSEA contribution: Systems deployed at ODYSSEA Observatories, including the Modular Seafloor Lander type B x 1, the Glider Payload 3 and the Surface Monitoring type A/B sensor systems, will have **microplastic sensors**. These sensors will make near-real time measurements of microplastic count and classification. The characteristics of the sensor systems allow the sensors to collect data from different points in the water column:

- The Modular Seafloor Lander is an autonomous system which will be lowered to the bottom of the sea to collect information on the seafloor.
- The gliders have several navigation modes:
    - Surveying – glider goes up and down in a forward projection
    - Virtual mooring – glider stays static at one point
    - Seabed anchored – glider dives, lands on the seabed floor and inflects up
    - Drift – on the surface or at an impression depth
- The surface monitoring systems will be mounted to certain structures (fish farm nets, mussel farms, oil platforms, etc.).

The **Delft3D-PART modelling system** will be implemented in selected Observatories (where the microplastics sensors will be installed) to estimate the dynamic, spatial concentration distribution of individual litter particles. Delft3D-PART couples a particle-tracking module with the hydrodynamic 3D model to represent the transport of litter. River discharges and associated amounts of floating litter enter the model and their fate is modelled according to local circulation forecasts.

The **MEDSLIK-II plastics/microplastics tracking modelling system** will be implemented in selected Observatories (where the microplastics sensors will be installed). This will be used to estimate the distribution of plastics/microplastics at the surface (floating), in the water column, benthic sediments, and the coasts, and to identify accumulation zones.

Knowledge gap: Need to understand links between hydrodynamic factors to assess transport dynamics and accumulation zones.

Potential ODYSSEA contribution: Models, resolution and coverage will be standardised across all ODYSSEA Observatories, including:

- **Delft3D-FLOW Hydrodynamic modelling system** in all Observatories
- **Delft3D-PART Plastic dispersion modelling system** in selected Observatories

A Forecasting System will couple these hydrodynamic and marine litter dispersion models, to produce hourly data of three-dimensional currents, sea level, water temperature, salinity and density at each grid cell.

4.8 Energy including underwater noise (EO11)

Ecological Objective 11: Noise from human activities cause no significant on marine and coastal ecosystems.

Note: While Ecological Objective 11 was not assessed in the 2017 MED QSR, it is included here as the sensor systems that will be deployed at the ODYSSEA Observatories (in particular, Glider Payload 2) are expected to provide useful data for the assessment of underwater noise and the impact this has on cetacean distribution.

Candidate Indicator 26: Proportion of days and geographical distribution where loud, low, and mid-frequency impulsive sounds exceed levels that are likely to entail significant impact on marine animal

Knowledge gap: Need data on underwater noise.

Potential ODYSSEA contribution: Data from the Glider Payload 2 can provide required data for the assessment of underwater noise and the threat/impact this has on cetacean distribution.

Candidate Indicator 27: Levels of continuous low frequency sounds with the use of models as appropriate

Knowledge gap: Need data on underwater noise.

Potential ODYSSEA contribution: Data from the Glider Payload 2 can provide required data for the assessment of underwater noise and the threat/impact this has on cetacean distribution.

5 Recommendations and next steps

The 'gap analysis' presented here suggests that the data and information services that are in development for the ODYSSEA Platform could contribute to filling some of the current knowledge gaps for 12 of the 27 IMAP Common Indicators, supporting more comprehensive and integrated monitoring of seven Ecological Objectives. Notably, the three thematic clusters of the QSR, under which the 11 Ecological Objectives are organised – land and sea-based pollution, biodiversity and ecosystems, 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 Table 5 we propose a set of priority areas for collaboration between ODYSSEA and IMAP, focusing on the new data products from ODYSSEA sensors and models. These recommendations are based on the findings of this 'gap analysis', information gathered at the Regional Meeting on IMAP Implementation: Best Practices, Gaps and Common Challenges (Rome, Italy, 10-12 July 2018), and informal discussions with colleagues from the UNEP/MAP Coordinating Unit and the Specially Protected Areas Regional Activity Centre (SPA/RAC).

The ODYSSEA Platform and Observatories are expected to be fully operational by the end of the project in November 2021, with the aim to continue operating self-sustained after this. We suggest a two-step approach for the alignment between ODYSSEA and IMAP:

1) Medium-term: ODYSSEA data and services could contribute to the preparation of the next Mediterranean Quality Status Report in 2023.

2) 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 efforts under IMAP.

Proposed next steps to take the collaboration between ODYSSEA and IMAP forward are:

- To share the 'gap analysis' with ODYSSEA partners, UNEP/MAP and Regional Activity Centres for validation;
- To share the 'gap analysis' with the IMAP country focal points of the Contracting Parties to explore the possibility of integrating ODYSSEA Observatories into national monitoring programmes;
- To determine the data requirements, data flow processes and interoperability between the ODYSSEA Platform and the IMAP Info System in conversation with INFO/RAC, SPA/RAC and the UNEP/MAP Coordinating Unit;
- For ODYSSEA to closely follow the IMAP implementation process (e.g. attending 'Correspondence Group on Monitoring' meetings (CORMON)).

Table 4: Priority areas for collaboration between ODYSSEA and IMAP, particular focus on marine mammals and marine litter (in blue)

2017 QSR clusters	Ecological Objectives	Common Indicators	ODYSSEA data services	ODYSSEA sensor systems and models
Biodiversity and ecosystems	Biodiversity and ecosystems (EO1)	Species distributional range of marine mammals (CI3 MM)	Marine mammal distribution and abundance	In situ sensor systems
		Population abundance of marine mammals (CI4 MM)		
Land and sea-based pollution	Eutrophication (EO5)	Concentration of key nutrients in the water column (CI13)	Key nutrient concentration	In situ sensor systems Delft3D-WAQ water quality model
		Chlorophyll *a* concentration in the water column (CI14)	Chlorophyll *a* concentration	In situ sensor systems Delft3D-WAQ water quality model
	Pollution (EO9)	Concentration of key harmful contaminants (CI17)	Concentration of key harmful contaminants in the water column	Delft3D-WAQ water quality model
			Identification of harmful algal blooms	Remote sensing level 2 data (Sentinel 3)
		Occurrence, origin, extent of acute pollution events […] (CI19)	Accidental oil spills from ships	Remote sensing level 2 data (Sentinel 2)
			Extent, trajectory and concentration of oil spills	Delft3D-PART model MEDSLIK-II oil spill fate and transport model
	Marine litter (EO10)	Trends in the amount of litter washed ashore and/or deposited on coastlines […] (CI22)	Estimation of plastics/microplastics sources	MEDSLIK-II plastics/microplastics tracking model
			Beach litter distribution	Citizen science apps
		Trends in the amount of litter in the water column including microplastics and on the seafloor (CI23)	Litter abundance and type	In situ sensor systems
			Estimation of dynamic spatial concentration distribution of particles	Delft3D-PART plastic dispersion model
			Estimation of plastic/microplastic distribution at the surface, in the water column, benthic sediments, and coasts	MEDSLIK-II plastics/microplastics tracking model
	Underwater noise (EO11)	[Temporal] and geographical distribution of loud, low and mid-frequency impulsive sounds […] (CI26)	Data on underwater noise	In situ sensor systems
Land and sea interactions and processes	Hydrography (EO7)	Location and extent of the habitats impacted directly by hydrographic alterations (CI15)	Hydrographic conditions (currents, waves, suspended loads, etc.)	Delft3D-FLOW hydrodynamic model Delft3D-WAQ-SPM suspended sediment model
			Seagrass dynamics and distribution	Machine learning tools