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NECCTON

NEW COPERNICUS CAPABILITY FOR TROPHIC OCEAN NETWORKS

Deliverable D8.1

Technical specification of the pollutants and stressors products

Deliverable Contributors:	Name	Organisation	Role / Title
Deliverable Leader	Donata Canu	OGS	WP Lead
Contributing Author(s)	Ginevra Rosati	OGS	WP Contributor
	George Triantafyllou	MINDS	WP Contributor
	Ioannis Tamvakis	HCMR-MINDS	WP Contributor
	Kostas Tsiaras	HCMR	WP Contributor
	Erik Van Sebille	UU	WP Contributor
	Michael Denes	UU	WP Contributor
	Svitlana Liubartseva	CMCC	WP Contributor
	Johannes Bieser	HEREON	WP Contributor
	Zhiyong Xie	HEREON	WP Contributor
	Olivier Beauchard	NIOZ	WP Contributor
	Karline Soetaert	NIOZ	WP Contributor
	Giovanni Galli	PML	WP Contributor
Reviewer(s)	Aurore Biardeau	MIO	Internal Reviewer
	Francesco Regoli	UNIVPM	External Reviewer

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Preface

This document is the deliverable D8.1 of the Task 8.1 of NECCTON. Its objective is to define the product and services for the Pollutants and stressors components of ocean ecosystem, co-developed by work-package 8 and the project stakeholders.

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Glossary

Product	In NECCTON, a "product" is the output of a model, or of a coupled model, developed in the project. The product is assessed as a potential new variable for the Copernicus Marine Service. Each product can be delivered as a number of co-products, e.g., by different models in different regions. Each co-product is composed of a set of sub-variables and delivered as a model-output dataset.
Sub-variable	In NECCTON, a sub-variable is a single component of the product that is simulated by the model and used to estimate the desired product. For example, suspended particular matter is a product that may be estimated as the sum of sub-variables representing matter with different sizes.
Dataset	The NECCTON products will be delivered in the form of "datasets". These are aggregations of model outputs or observations, having the same geospatial structure or feature type (e.g., profiles, point-series, trajectories, points, grid-series, grids). A dataset contains data relative to one or more products developed by NECCTON. It is composed of one or several data files. The aggregation is done so that the content of the dataset is FAIR for the user (findable, accessible, interoperable, and reusable) and expandable when the product is updated (time axis).
Datacube	The NECCTON "datacube exploratory viewer" is an interactive application for exploring and visualizing the datasets, adapted to the visualization of the NECCTON products simulated by the integrated ecosystem model. This datacube is based on innovative cloud-based technologies and will use a serverless architecture that allows it to connect directly to files and not to a server. This viewer will guarantee high-availability, visual analysis, and flexible data dissemination to the users
Service	In NECCTON, a service is a tool (e.g., software) that transforms the data of a product into information needed by a stakeholder for a specific application. Most notably, the NECCTON datacube is a service that will map features of the data selected by the user.
Derived product	In NECCTON, a derived product is the output of a service, which is calculated from an original product and other relevant information, in response to user needs. For example, the space-time occurrence of suspended particulate matter above chosen thresholds is a derived product, that could be an output of the NECCTON datacube.

Publishable Summary

This report contains detailed information on the novel products for the Copernicus Marine Service concerning pollutants (mercury, plastic, oil, and different families of POPs) and stressors (bottom trawl fishery, climate change, and multiple stress) that will be delivered by NECCTON WP8. It provides specifications about the variables embedded in each product (Section 3). The different products are applied to different geographic areas (North-West European Shelf, Mediterranean Sea, Black Sea, and Arctic), as described in the dataset tables (Section 4).

1. Introduction

1.1 Scope of document

The objective of this document is to provide a clear definition of the pollutants and stressors products that will be delivered by NECCTON WP8, and to serve as a reference for internal and external users of the products. The definition is based on the requirements of users that emerged from the NECCTON workshop “Co-design of future products” which was held on-line in June 2023 (more than 100 stakeholders attending) and the survey “Product co-design” held from July to September 2023 (more than 220 respondents). In this document, the definition of the products includes a brief review of previous and ongoing efforts in defining and delivering the product in an operational framework, as well as a description of the expected exploitation by users and associated impact.

This document also describes the model datasets produced by NECCTON to deliver the product to internal and external users. Such descriptions include a reference to the model producing the dataset, as well as features of the data, such as their spatial coverage and resolution, temporal extension and resolution. It also includes a description of the metadata provided in the files containing the datasets. The observations expected to be compared to the model data are also listed.

The models that will be developed by NECCTON WP8 as well as the accuracy and precisions of the products will be assessed using observations and quantitative metrics, consistently with the Copernicus Marine Service validation protocols, and will be the object of future deliverables.

We recall that all the products and datasets delivered by NECCTON follow the FAIR principles: they are findable, accessible, interoperable and reusable (see the “Data Management Plan” D1.1). In particular, NECCTON datacube is the main service for the dissemination and use of the products and datasets described here. Therefore, this document describes the compatibility of the datasets with the datacube.

We point out that the models producing the datasets in WP8, the datacube developed in WP2 and potential derived products are the specific focus of other future deliverables of NECCTON. Therefore, the description is out of the scope of the present document.

We note that the terminology in the glossary is consistent with the one provided by GOOS, an Intergovernmental Oceanographic Commission (IOC)-led programme, in the Specification Sheets

related to the Essential Ocean Variables defined by the Expert Panels of the Global Ocean Observing System (GOOS) (https://www.goosocean.org). Whenever available, we used the Climate and Forecast (CF) standard metadata conventions or criteria to define the metadata of the NECCTON products and sub-variables (e.g., long-names, units; https://cfconventions.org/). When these were not available, we made here new propositions, following the CF criteria, that might be refined through the engagement of experts and users during the future delivery of the project, by using this document as a discussion platform.

1.2 Intended audience and reference to user needs

This document is designed as a guide for the NECCTON partners as well as future users of the new products delivered by WP8 of NECCTON. WP8 is working closely with WP1 (Management), WP 2 (Stakeholders) and WP9 (Case studies) to ensure that these products correspond to user needs.

The user needs for the WP8 products emerged from the session "Marine pollution and stressors modeling" of the NECCTON workshop "Co-design of future products" held on-line in June 2023 (with 21 stakeholders attending the specific session) and the WP8 dedicated section of the survey "Product co-design", held from July to September 2023 (more than 220 respondents).

An analysis of the attendants and results of the above workshop session and survey section indicated that the potential users of the WP8 products fell in the following categories:

- Academics (71%),
- Policy makers (14 %),
- NGOs representatives (10 %),
- Private sector representatives (5 %)

A wide range of applications was reported, spanning from Marine Spatial Planning to the management of Marine Protected Areas, "Natura 2000" sites and exclusive economic zones. Other areas concern human health and food safety and impact studies on aquaculture, acidification, marine traffic, deep sea mining, oil and gas exploitation, and offshore wind energy. The attendants also report a great interest on cumulative stressors assessments. The socio-economic targets identified as most sensitive to pollutants are fishery, tourism, and the coastal communities. Target commercial species for pollution impacts and bioacumulation include cod, hake, herrings, sea bass, sea bream, mussels, clams and other shellfish, and seaweed. Other receptors of interest are marine mammals, corals, sea turtles, eels, maerl beds, Posidonia and other seagrass meadows.

The feedback, expected use and impact for each single product, based on the analysis of the results, is provided is Section 3.

The engagement of the stakeholders to tailor the WP8 NECCTON products to the user needs will continue throughout the duration of the project by co-designing thirteen case studies, dedicated workshops and engaging other European projects, initiatives and networks (including the Copernicus Marine Service user groups, the EDITO-Model Lab Project https://www.edito-modellab.eu/, the GOA-ON, Global Ocean Acidification Observig Network http://www.goa-on.org/, the CoastPredict project

https://www.coastpredict.org/, and the Multi-Compartment Hg Modeling and Analysis Project https://htap.org/tf-htap-update-and-upcoming-meetings/#_Multi-Compartment_Mercury_Modeling).

1.3 Structure of the document

The document is structured as follows. Section 2 provides a synthetic list of the products that will be delivered by WP 8. Section 3 provides a thorough description of each product, including: i) a general definition; ii) the user requirements, iii) the current state of the art, iv) planned evolution of the product delivery, v) the observations expected to be used to assess the model datasets, vi) the expected exploitation and impact of the product, and vii) key metadata of the product. Section 4 describes the datasets planned in NECCTON to deliver the products to users. A summary of possible challenges and expected impacts is given in Section 5.

2. Products summary

The NECCTON products (see definition in the glossary) that are delivered by WP 8 are listed in Table 2.1, along with selected, high-level information. This provides the reader and product users with an overview of the data delivered by NECCTON, as well as with identifiers to retrieve the product and dataset specifications in Sections 3 and 4. The datasets are delivered by hindcasts (H), i.e. model simulations of the past, which are named with unique numeric identifiers (H1, H2, ….).

Table 2.1 List of the co-products delivered by WP 8. First column: name of the product; second column: product ID; third column: ID dataset used to support the development of the product; fourth column: Copernicus Marine Service region; fifth column: model to be used for creating the product; and sixth column: NECCTON partner responsible for delivering the product.

Name product	ID co.product	ID datasets	Region	Partners
Plastic	19.1	H31	Mediterranean Sea (MED)	MINDS
Plastic	19.2	H33	North-West European shelf-seas (NWS)	UU
Plastic	19.2	H34	Arctic Ocean (ARC)	UU
POPs (PCB)	20.1	H37	Global (GLO)	HEREON
POPs (PFAS)	20.2	H38	Global (GLO)	HEREON
Mercury	21.1	H30	Mediterranean Sea (MED)	OGS
Mercury	21.2	H35	Global (GLO)	HEREON
Oil	22	H32	Mediterranean Sea (MED)	CMCC
Fisheries pressure	23	H42	Black Sea (BS)	NIOZ
Climate change stressor index	24	H43	North-West European shelf-seas (NWS)	PML

Multi-stressor index	25	H44	North-West European shelf-seas (NWS)	PML

3. Product definition

The next sections provide thorough definitions of each product listed in table 2.1.

3.1 Product Mercury

3.1.0 Introduction

Mercury (Hg) is a persistent, bioaccumulative, toxic pollutant. In the ocean, inorganic Hg is converted into neurotoxic methylmercury (MeHg) that bioaccumulates and biomagnifies in marine food webs, raising a concern for wildlife and human health. MeHg production is thought to be an incidental process associated with the microbial degradation of organic matter in the water column and seabed. The use and production of mercury has declined significantly in recent decades as a result of the global commitment of the Minamata Convention to ban new mercury mines, phase out existing ones, phase out the use of mercury in a range of products and processes, and take action to control emissions. However, since mercury has been emitted to the environment for centuries as it has been used for several industrial and commercial applications, legacy Hg continues cycling through the biosphere adding up to new “primary” emissions and to background emissions from natural sources, as in the case of the Mediterranean area. Improving the capability to simulate these dynamics, as well as the uptake of Hg at the base of marine food webs, is crucial for environmental management.

3.1.1 User feedback and requirements

About 18% of the respondents to the survey (40 people) declared an interest in Mercury products. These stakeholders are from 25 different countries, with the most represented being Indonesia (10%), France, (7.6%), Italy (7.6%), Algeria (5%), Norway (5%), Poland (5%), and Spain (5%). The respondents interested in Mercury products are from the following sectors: “Education, Public Health & Recreation” (70%), “Climate and Adaptation” (65%), “Marine food” (60%), “Coastal services” (50%) , “Ocean Health” (45%), “Extremes, Hazards & Safety” (45%), “Polar Environment Monitoring” (37.5%), “Trade & Marine Navigation” (32%), “Natural Resources & Energy” (27%), and “Policies, Ocean Governance & Mitigation” (12%).

Most of the stakeholders work at regional (65%) or national (45%) scale, but also at global (37.5%) and local (32.5%) scale. They are interested in the Copernicus products to conduct scientific research and analysis (92%) to assess and monitor the health of marine ecosystems (50%), develop conservation and management strategies (50%), and inform policy and decision-making processes (43%). About 30% of the respondents are also interested in support educational or awareness initiatives. The required spatial resolution spans from 1-2 km to less than 20 km, with some stakeholders highlighting a general need for “good” (high) spatial resolution at coastal sites. Temporal resolutions of interest span from monthly to seasonal.

3.1.2 State-of-the-art on product delivery and gaps

Currently, the Copernicus Marine Service lacks products dealing with mercury in the ocean. More in general, to the best of our knowledge no operational products of this kind are available worldwide. The development of new products related to Hg will support improved capability to assess the state of regional European seas regarding pollution and bioaccumulation. The products will include different species of Hg in seawater, organic particles, and different plankton groups. A first order assessment of bioaccumulation in fish is also provided with the sub-variables Hg and MMHg in fish, aimed at representing a whole-body generic forage fish.

3.1.3 How NECCTON will innovate the product and fill the gap

Novel tools recently developed to simulate the Hg cycle in the ocean (Bieser et al., 2023; Rosati et al., 2022) will be refined, upgraded, and harmonized to deliver comprehensive dataset for European regional seas.

3.1.4 Observational data available for product calibration/assimilation/validation

Mediterranean Sea: a dataset including all published and unpublished observational data of mercury species in the water column is under compilation in the NECCTON project.
Global: a dataset including all published and unpublished observational data of mercury species in the water column is under compilation in the "Minamata and Long-Range Transboundary Air Pollution Conventions" initiative.

3.1.5 Expected users' uptake

The Hg products delivered with this project can be exploited in several ways. The distribution of methylmercury in different plankton PFTs can be used as a basis for exposure assessment for wildlife as well as an input for bioaccumulation models of HTL at basin or subbasin scale. A first order assessment of bioaccumulation in fish is also provided with the sub-variable Hg in biota, representing a generic fish. This information can be used to estimate human exposure.
The sub-variables provided, including concentrations of Hg species in water, can support the assessment of the status of water bodies, as required by the EU law, as well as studies on multiple stressors and/or the development of indexes related to anthropogenic pressures.
The distribution of Hg species in water can provide useful boundary condition for atmospheric models and for marine models with higher spatial resolutions (e.g., for coastal areas).

3.1.6 List of co-products, sub-variables and metadata in the data-files for this product

Co-product ID	**Co-product in bold and green shade**
	Sub-variable in bold and italic
21.1	**Mercury**
Sub-variable name [unit]	***Oxidized mercury*** [nmol m^{-3}]
Description	
Long name	Bulk oxidized mercury (dissolved and particulate)
Short name	HgII
Standard_name	mole_concentration_of_oxidized_mercury_in_sea_water

Sub-variable name [unit]	***Elemental mercury*** [nmol m^{-3}]
Description	
Long name	Gaseous elemental mercury
Short name	Hg0_g
Standard_name	mole_concentration_of_elemental_mercury_dissolved_in_sea_water
Sub-variable name [unit]	***Monomethylmercury*** [nmol m^{-3}]
Description	
Long name	Bulk monomethylmercury (dissolved and particulate)
Short name	MMHg
Standard_name	Mole_concentration_of_monomethylmercury_in_sea_water
Sub-variable name [unit]	***Dimethylmercury*** [nmol m^{-3}]
Description	
Long name	Gaseous dimethylmercury
Short name	DMHg_g
Standard_name	mole_concentration_of_gaseous_dimethylmercury_dissolved_in_sea_water
Sub-variable name [unit]	***MMHg in phytoplankton*** [nmol m^{-3}]
Description	
Long name	Monomethylmercury in phytoplankton
Short name	MMHg-PHY
Standard_name	mole_concentration_of_monomethylmercury_in_phytoplankton_due_to_bioconcentration
Sub-variable name [unit]	***MMHg to C in phytoplankton*** [nmol mgC^{-1}]
Description	
Long name	Ratio of Monomethylmercury to Carbon in phytoplankton
Short name	MMHg-C-PHY_bc
Standard_name	mole_concentration_of_monomethylmercury_in_phytoplankton_due_to_bioconcentration_expressed_as_ratio_per_biomass_carbon
Sub-variable name [unit]	***MMHg in zooplankton*** [nmol m^{-3}]
Description	
Long name	Monomethylmercury in zooplankton
Short name	MMHg-ZOO_bm
Standard_name	mole_concentration_of_monomethylmercury_in_zooplankton_due_to_bioaccumulation
Sub-variable name [unit]	***MMHg to C in zooplankton*** [nmol/g C]
Description	

Long name	Ratio of monomethylmercury to Carbon in zooplankton
Short name	MMHg-C-ZOO
Standard_name	mole_concentration_of_monomethylmercury_in_zooplankton_due_to_bioaccumulation_expressed_as_ratio_per_biomass_carbon

Co-product ID	**Co-product in bold and green shade**
	Sub-variable in bold and italic
21.2	**Mercury**
Sub-variable name [unit]	***Dissolved Oxidized mercury*** [nmol m^{-3}]
Description	
Long name	Dissolved oxidized mercury
Short name	HgII_d
Standard_name	mole_concentration_of_oxidized_mercury_dissolved_in_sea_water
Sub-variable name [unit]	***Particle bound inorganic mercury*** [n nmol m^{-3}]
Description	
Long name	Particulate oxidized mercury
Short name	HgII_p
Standard_name	mole_concentration_of_inorganic_mercury_bound_to_particulate_organic_matter_in_sea_water
Sub-variable name [unit]	***Dissolved elemental mercury*** [nmol m^{-3}]
Description	
Long name	Dissolved elemental mercury
Short name	Hg0_g
Standard_name	mole_concentration_of_elemental_mercury_dissolved_in_sea_water
Sub-variable name [unit]	***Cinnabar*** [nmol m^{-3}]
Description	
Long name	Cinnabar
Short name	HgS
Standard_name	mole_concentration_of_mercury_sulfide_in_sea_water
Sub-variable name [unit]	***Dissolved monomethylmercury*** [nmol m^{-3}]
Description	
Long name	Dissolved monomethylmercury
Short name	MMHg_d
Standard_name	mole_concentration_of_monomethylmercury_dissolved_in_sea_water
Sub-variable name [unit]	***Particulate monomethylmercury*** [nmol m^{-3}]
Description	

Long name	Particulate monomethylmercury
Short name	MMHg_p
Standard_name	mole_concentration_monomethylmercury_bound_to_particles_in_sea_water
Sub-variable name [unit]	***Particulate organic matter*** [mgC m^{-3}]
Description	
Long name	Particulate organic matter
Short name	POM
Standard_name	mass_concentration_of_particulate_organic_matter_expressed_as_carbon_in_sea_water
Sub-variable name [unit]	***Dimethylmercury*** [nmol m^{-3}]
Description	
Long name	Gaseous dimethylmercury
Short name	DMHg_g
Standard_name	mole_concentration_of_gaseous_dimethylmercury_dissolved_in_sea_water
Sub-variable name [unit]	***HgII in phytoplankton*** [nmol m^{-3}]
Description	
Long name	Inorganic mercury in phytoplankton
Short name	HgII_PHY_bc
Standard_name	mole_concentration_of_inorganic_mercury_in_phytoplankton_due_to_bioconcentration
Sub-variable name [unit]	***MMHg in phytoplankton*** [nmol m^{-3}]
Description	
Long name	Monomethylmercury in phytoplankton
Short name	MMHg_PHY_bc
Standard_name	mole_concentration_of_monomethylmercury_in_phytoplankton_due_to_bioconcentration
Sub-variable name [unit]	***HgII in phycosphere*** [nmol m^{-3}]
Description	
Long name	Inorganic mercury in phycosphere
Short name	HgII_PHYCOS
Standard_name	mole_concentration_of_monomethylmercury_in_phytoplankton_due_to_ mole_concentrations_of_inorganic_mercury_in_phycosphere
Sub-variable name [unit]	***MMHg in phycosphere*** [nmol m^{-3}]
Description	
Long name	Monomethylmercury in phycosphere

Short name	MMHg_PHYCOS
Standard_name	mole_concentrations_of_methyl_mercury_in_phycosphere
Sub-variable name [unit]	***Phytoplankton*** [mgC m^{-3}]
Description	
Long name	Phytoplankton mass density
Short name	PHY
Standard_name	mass_concentration_of_phytoplankton_expressed_as_carbon_in_sea_water
Sub-variable name [unit]	***HgII adsorbed onto zooplankton*** [nmol m^{-3}]
Description	
Long name	Inorganic mercury adsorbed onto zooplankton
Short name	HgII_ZOO_bc
Standard_name	mole_concentration_of_inorganic_mercury_in_zooplankton_due_to_bioconcentration
Sub-variable name [unit]	***MMHg adsorbed onto zooplankton*** [nmol m^{-3}]
Description	
Long name	Monomethylmercury adsorbed onto zooplankton
Short name	MMHg_ZOO_bc
Standard_name	mole_concentration_of_methyl_mercury_in_zooplankton_due_to_bioconcentration
Sub-variable name [unit]	***HgII absorbed into zooplankton*** [nmol m^{-3}]
Description	
Long name	Inorganic Hg absorbed into zooplankton
Short name	HgII_ZOO_bm
Standard_name	mole_concentration_of_inorganic_mercury_in_zooplankton_due_to_biomagnification
Sub-variable name [unit]	***MMHg absorbed into zooplankton*** [nmol m^{-3}]
Description	
Long name	Monomethylmercury absorbed into zooplankton
Short name	MMHg_ZOO_bm
Standard_name	mole_concentration_of_methyl_mercury_in_zooplankton_due_to_biomagnification
Sub-variable name [unit]	***Zooplankton [***mgC m^{-3}] *
Description	
Long name	Zooplankton mass density
Short name	ZOO

Standard_name	mass_concentration_of_zooplankton_expressed_as_carbon_in_sea_water
Sub-variable name [unit]	***HgII in sediment*** [nmol m^{-2}]
Description	
Long name	Inorganic mercury in sediment
Short name	HgII_SED
Standard_name	mole_concentration_of_inorganic_mercury_in_sediment_top_layer
Sub-variable name [unit]	***MMHg in sediment*** [nmol m^{-2}]
Description	
Long name	Monomethylmercury in sediment
Short name	MMHg_SED
Standard_name	mole_concentration_of_methly_mercury_in_sediment_top_layer
Sub-variable name [unit]	***HgII bioconcentrated in macrobenthos*** [nmol m^{-2}]
Description	
Long name	Inorganic mercury bioconcentrated in macrobenthos
Short name	HgII_MAC_bc
Standard_name	mole_concentrations_of_inorganic_mercury_in_macrobenthos_due_to_bioconcentration
Sub-variable name [unit]	***MMHg bioconcentrated in macrobenthos*** [nmol m^{-2}]
Description	
Long name	Monomethylmercury bioconcentrated in macrobenthos
Short name	MMHg_MAC_bc
Standard_name	mole_concentrations_of_methyl_mercury_in_macrobenthos_due_to_bioconcentration
Sub-variable name [unit]	***HgII biomagnified*** [nmol m^{-2}]
Description	
Long name	Inorganic mercury biomagnified in macrobenthos
Short name	HgII_MAC_bm
Standard_name	mole_concentrations_of_inorganic_mercury_in_macrobenthos_due_to_biomagnification
Sub-variable name [unit]	***MMHg biomagnified in macrobenthos*** [nmol m^{-2}]
Description	
Long name	Monomethylmercury biomagnified in macrobenthos
Short name	MMHg_MAC_bm
Standard_name	mole_concentrations_of_methyl_mercury_in_macrobenthos_due_to_biomagnification

Sub-variable name [unit]	***Macrozoobenthos biomass*** [mgC m^{-2}]
Description	
Long name	Macrozoobenthos biomass
Short name	MAC
Standard_name	mole_concentration_of_macrozoobenthos_expressed_as_carbon_per_unit_surface_of_bottom_sediment
Sub-variable name [unit]	***HgII mercury in fish*** [nmol m^{-3}]
Description	
Long name	Inorganic mercury in fish due to bioconcentration
Short name	HgII_FISH_bc
Standard_name	mole_concentrations_of_inorganic_mercury_in_fish_due_to_bioconcentration
Sub-variable name [unit]	***MMHg mercury in fish*** [nmol m^{-3}]
Description	
Long name	Monomethylmercury in fish due to bioconcentration
Short name	MMHg_FISH_bc
Standard_name	mole_concentrations_of_methyl_mercury_in_fish_due_to_bioconcentration
Sub-variable name [unit]	***HgII mercury in fish*** [nmol m^{-3}]
Description	
Long name	Inorganic mercury in fish due to biomagnification
Short name	HgII_FISH_bm
Standard_name	mole_concentrations_of_inorganic_mercury_in_fish_due_to_biomagnification
Sub-variable name [unit]	***MMHg mercury in fish*** [nmol m^{-3}]
Description	
Long name	Monomethylmercury in fish due to biomagnification
Short name	MMHg_FISH_bm
Standard_name	mole_concentrations_of_methyl_mercury_in_fish_due_to_biomagnification_
Sub-variable name [unit]	***Fish biomass*** [mgC m^{-3}]
Description	
Long name	Fish biomass
Short name	FISH
Standard_name	mass_concentration_of_fish_expressed_as_carbon_in_sea_water
* available CF metadata (https://cfconventions.org/) If not starred, the metadata is newly proposed in NECCTON	

3.2 Product Plastic

3.1.0 Introduction

A significant amount of plastics currently ends up in the marine environment, raising concern for wildlife and human health. Plastics affect marine organisms through ingestion and/or entanglement, while microplastics that represent the smaller size class (particles <5 mm), may interact with low trophic-level organisms (i.e., phytoplankton and zooplankton) and their predators, finding their way up the food chain and human diet. Microplastics are either primary (personal care products, pre-production pellets) or secondary, originating from the fragmentation of larger items. Plastics in the marine environment originate from both land-based sources (coastlines ~39-42%, rivers 12-13%) and sea-based sources (fishing activities 45-48%), with their fate being determined by various physical (waves, currents, wind) and biogeochemical (e.g., biofouling) processes. Thus, models taking into account the most important processes and source inputs provide powerful tools for the assessment of marine litter pollution.

3.2.1 User feedback and requirements

Plastic is near the top of the list of products that are in demand, according to the survey. 120 of the 206 responders to the question “Are you interested in any of the following stressor and pollutant products?” answered in favour of plastic, the second most popular choice after the more general “Climate change stressor index”. Plastic is also a popular answer when responders are asked to identify the main threats and pressures to the sea and ocean. One responder identified a lack of observations of marine plastic pollution, while noting the lack of standardisation for the few that are present. A range of temporal periods were requested; 106 responders wanted “Recent past data”, 89 responders wanted “Near-real-time data”, and 58 responders wanted “Forecasts (up to 10 days)”. A range of temporal resolutions were requested; 50 responders wanted “Yearly”, 77 responders wanted “Monthly”, 41 responders wanted “Weekly”, 83 responders wanted “Daily”, 61 responders wanted “Hourly”, and 23 responders wanted “Less than 15 minutes”. A range of spatial resolutions were requested; 64 responders wanted “Below 1km”, 43 responders wanted “A few kms”, 7 responders wanted “Tens of kms”, and 3 responders wanted “1 degree or more”. Additionally, 90 responders requested “Vertically resolved data (3D in space)”, and 70 responders requested “Depth averaged data (2D in space)”. In summary, approximately 54% of the respondents to the survey (120 people) declared an interest in Plastic products. These stakeholders are from 59 different countries, with the most represented being Italy (13%), Indonesia (8%), Spain (4%), United Kingdom (4%), Mexico (3%), France (3%), Norway (3%), China (3%), United States (3%), Portugal (3%), and India (3%). The remaining 48 countries represented between 1-2% of the respondents. The respondents interested in Plastic products are from the following sectors: “Marine Conservation & Biology” (64%), “Climate & Adaptation” (59%), “Coastal Services” (55%), “Science & Innovation” (52%), “Ocean Health” (43%), “Policies, Ocean Governance & Mitigation” (33%), Natural Resources & Energy” (30%), “Extremes, Hazards & Safety” (28%), “Education, Public Health & Recreation” (18%), “Marine Food” (18%), “Polar Environment Monitoring” (17%), and “Trade & Marine Navigation” (12%).

3.2.2 State-of-the-art on product delivery and gaps

Currently, Copernicus Marine does not provide products related to plastic pollution in the marine environment. More in general, to the best of our knowledge no operational products of this kind are available at the global scale. The development of new products related to plastics will support the ability to assess the environmental status of European regional seas regarding marine litter pollution. The products will include concentration maps of micro- and macro-plastic pollution from different sources, such as coastlines, rivers, and fisheries.

3.2.3 How NECCTON will innovate the product and fill the gap

Lagrangian modelling tools have been recently developed to simulate the fate of plastics, originated from land-based sources in the Mediterranean (Tsiaras et al., 2021; Tsiaras et al., 2022; Hatzonikolakis et al., 2022), and land- and sea-based sources in the global ocean (Kaandorp et al. 2023). These will be further upgraded and refined during NECCTON, including a better representation of microplastics size distribution and a model parameterization for plastics fragmentation. The new harmonised dataset that will be delivered in the Copernicus system will include the spatial distribution for different sizes of plastics, providing support for the assessment of plastic pollution and its management. In addition, we will refine and upgrade the Parcels framework (Delandmeter and van Sebille 2019), and develop a series of fine-scale physics parameterisations (in the form of custom "kernels") to model micro-plastic transport in the Arctic and North-West European Shelf regions.

3.2.4 Observational data available for product calibration/assimilation/validation

All currently available observational data from databases (EMODNET, EEA, NOAA) and publications are currently compiled within the NECCTON project.

3.2.5 Expected users' uptake

The new plastics product, delivered with NECCTON can be exploited in several ways. The provided concentration and spatial distribution of plastics can be used to identify hot-spot/ accumulation areas in the marine environment, particularly in relation with ecologically and commercially important areas (e.g. Marine protected areas, aquaculture etc.). The product will also provide support for the implementation of MSFD Descriptor 10 for the good environmental status with regard to marine litter pollution. It can also be used to gain a better understanding on the dynamics and pathways of plastics in the marine environment.

3.2.6 List of co-products, sub-variables and metadata in the data-files for this product

Co-product ID	**Co-product in bold and green shade**
	Sub-variable in bold and italic
19.1	**Plastics**
Sub-variable name [unit]	***Microplastics >0.3mm surface*** [item km^{-2}]
Description	
Long name	Total Surface (integrated 0-30cm depth) Concentration of Microplastic (>0.3mm) in Sea Water

Short name	MicroplTot
Standard_name	surface_concentration_of_total_microplastic_in_sea_water
Sub-variable name [unit]	***Microplastics 0.3-0.4 mm Surface*** [item km^{-2}]
Description	
Long name	Surface Concentration (integrated 0-30cm depth) of Microplastics with size 0.3-0.4mm in Sea Water
Short name	Micropl1
Standard_name	surface_concentration_of_microplastic_class1_in_sea_water
Sub-variable name [unit]	***Microplastics 0.4-0.6 mm Surface*** [item km^{-2}]
Description	
Long name	Surface Concentration (integrated 0-30cm depth) of Microplastics with size 0.4-0.6mm in Sea Water
Short name	Micropl2
Standard_name	surface_concentration_of_microplastic_class2_in_sea_water
Sub-variable name [unit]	***Microplastics 0.6-1.5 mm Surface*** [item km^{-2}]
Description	
Long name	Surface Concentration (integrated 0-30cm depth) of Microplastics with size 0.6-1.5mm in Sea Water
Short name	Micropl3
Standard_name	surface_concentration_of_microplastic_class3_in_sea_water
Sub-variable name [unit]	***Microplastics 1.5-2.5 mm surface*** [item km^{-2}]
Description	
Long name	Surface Concentration (integrated 0-30cm depth) of Microplastics with size 1.5-2.5mm in Sea Water
Short name	Micropl4
Standard_name	surface_concentration_of_microplastic_class4_in_sea_water
Sub-variable name [unit]	***Microplastics 2.5-5 mm Surface*** [nmol mgC^{-1}]
Description	
Long name	Surface Concentration (integrated 0-30cm depth) of Microplastics with size 2.5-5mm in Sea Water
Short name	Micropl5
Standard_name	surface_concentration_of_microplastic_class5_in_sea_water
Sub-variable name [unit]	***Microplastics >0.3mm Water column*** [item km^{-3}]

Description	
Long name	Total concentration of Microplastic items of size <0.3mm in the sea water column
Short name	MicroplTot-3D
Standard_name	concentration_of_total_microplastic_in_sea_water
Sub-variable name [unit]	***Macroplastics 5-20 mm*** [item km^{-2}]
Description	
Long name	Surface Concentration (integrated 0-30cm depth) of Macroplastics with size 5-20mm in Sea Water
Short name	Macropl1
Standard_name	surface_concentration_of_macroplastic_class1_in_sea_water
Sub-variable name [unit]	***Macroplastics 20-200 mm*** [item km^{-2}]
Description	
Long name	Surface Concentration (integrated 0-30cm depth) of Macroplastics with size 20-200mm in Sea Water
Short name	Macropl2
Standard_name	surface_concentration_of_macroplastic_class2_in_sea_water
Sub-variable name [unit]	***Macroplastics >200 mm*** [item km^{-2}]
Description	
Long name	Surface Concentration (integrated 0-30cm depth) of Macroplastics with size >200mm in Sea Water
Short name	Macropl3
Standard_name	surface_concentration_of_macroplastic_class3_in_sea_water

Co-product ID	**Co-product in bold and green shade**
	Sub-variable in bold and italic
19.2	**Plastics**
Sub-variable name [unit]	***Microplastics > 0.3mm Surface*** [item km^{-2}]
Description	
Long name	Total Surface Concentration (integrated 0-30cm depth) of Microplastic (>0.3mm) in Sea Water
Short name	MicroplTot
Standard_name	surface_concentration_of_total_microplastic_in_sea_water
Sub-variable name [unit]	***Microplastics 0.3-0.4mm Surface*** [item km^{-2}]
Description	

Long name	Surface Concentration (integrated 0-30cm depth) of Microplastics with size 0.3-0.4mm in Sea Water
Short name	Macropl1
Standard_name	surface_concentration_of_microplastic_class1_in_sea_water
Sub-variable name [unit]	***Microplastics 0.4mm – 0.6mm Surface*** [item km $^{-2}$]
Description	
Long name	Surface Concentration (integrated 0-30cm depth) of Microplastics with size 0.4-0.6mm in Sea Water
Short name	Micropl2
Standard_name	surface_concentration_of_microplastic_class2_in_sea_water
Sub-variable name [unit]	***Microplastics 0.6-1.5mm Surface*** [item km $^{-2}$]
Description	
Long name	Surface Concentration (integrated 0-30cm depth) of Microplastics with size 0.6-1.5mm in Sea Water
Short name	Micropl3
Standard_name	surface_concentration_of_microplastic_class3_in_sea_water
Sub-variable name [unit]	***Microplastics 1.5-2.5mm Surface*** [item km $^{-2}$]
Description	
Long name	Surface Concentration (integrated 0-30cm depth) of Microplastics with size 1.5-2.5mm in Sea Water
Short name	Micropl4
Standard_name	surface_concentration_of_microplastic_class4_in_sea_water
Sub-variable name [unit]	***Microplastics 2.5-5mm Surface*** [item km $^{-2}$]
Description	
Long name	Surface Concentration (integrated 0-30cm depth) of Microplastics with size 2.5-5mm in Sea Water
Short name	Micropl5
Standard_name	surface_concentration_of_microplastic_class5_in_sea_water
Sub-variable name [unit]	***Microplastics > 0.3mm Water Column*** [item km^{-3}]
Description	
Long name	Total Concentration of Microplastics in the Water Column in Sea Water
Short name	MicroplTot-3D
Standard_name	concentration_of_total_microplastic_in_sea_water
Sub-variable name [unit]	***Microplastics 0.3-0.4mm Water Column*** [item km^{-3}]

Description	
Long name	Concentration of Microplastics in the Water Column with size 0.3-0.4mm in Sea Water
Short name	Micropl1-3D
Standard_name	concentration_of_microplastic_class1_in_sea_water
Sub-variable name [unit]	***Microplastics 0.4mm – 0.6mm Water Column*** [item km^{-3}]
Description	
Long name	Concentration of Microplastics in the Water Column with size 0.4-0.6mm in Sea Water
Short name	Micropl2-3D
Standard_name	concentration_of_microplastic_class2_in_sea_water
Sub-variable name [unit]	***Microplastics 0.6-1.5m Water Column*** [item km^{-3}]
Description	
Long name	Concentration of Microplastics in the Water Column with size 0.6-1.5mm in Sea Water
Short name	Micropl3-3D
Standard_name	concentration_of_microplastic_class3_in_sea_water
Sub-variable name [unit]	***Microplastics 1.5-2.5mm Water Column*** [item km^{-3}]
Description	
Long name	Concentration of Microplastics in the Water Column with size 1.5-2.5mm in Sea Water
Short name	Micropl4-3D
Standard_name	concentration_of_microplastic_class4_in_sea_water
Sub-variable name [unit]	***Microplastics 2.5-5 mm Water Column*** [item km^{-3}]
Description	
Long name	Concentration of Microplastics in the Water Column with size 2.5-5mm in in Sea Water
Short name	Micropl5-3D
Standard_name	concentration_of_microplastic_class5_in_sea_water

3.3 Product Oil

3.3.0 Introduction

Oil spills can seriously affect the marine biota both as a result of toxic effects and physical smothering. The severity of impact depends on the spill quantity, exposure time and type of oil, the environmental conditions and the sensitivity of the affected organisms and their habitats to the oil.

The toxic components of oil are low molecular weight aromatic compounds: monoaromatic and polynuclear aromatic hydrocarbons (MAHs and PAHs), which are both volatile and soluble in water. For example, the chemical components of kerosene have a higher biological availability and damage through toxicity is more likely. However, rapid dissipation, through evaporation and natural dispersion, means light oils may less damaging overall. In contrast, the highly persistent oil, such as a heavy fuel oil (HFO), has the potential to cause widespread damage through smothering. However, toxic effects are less likely for HFO, as the chemical components of oil have a low bioavailability.

3.3.1 User feedback and requirements

About 34% of the respondents to the survey (84 people) declared an interest in Oil products. These stakeholders are from 45 different countries, with the most represented being Indonesia (8%), Italy (7%), Brazil (5%), Algeria (4%), Canada (4%), Portugal (4%), Spain (4%), Australia (2%), China (2%), Croatia (2%), India (2%), Mexico (2%), Netherlands (2%), Norway (2%), Poland (2%), Ukraine (2%), UK (2%), USA (2%). There are also 27 countries which the remaining respondents are evenly distributed with a contribution of 1%. The respondents interested in Oil products are from the following sectors: “Coastal services” (58%), “Marine Conservation & Biodiversity” (51%), “Science & Innovation” (49%), “Climate and Adaptation” (46%), “Extremes, Hazards & Safety” (35%), “Ocean Health” (33%), “Policies, Ocean Governance & Mitigation” (32%), “Natural Resources & Energy” (32%), “Trade & Marine Navigation” (21%), “Marine food” (20%), “Polar Environment Monitoring” (20%), and “Education, Public Health & Recreation” (18%). Stakeholders required high temporal resolution (hourly-daily) for oil related products. The required spatial resolution is of a few kilometres (from 1-2 km to less than 20 km), with some stakeholders highlighting a general need for “good” (high) spatial resolution at coastal sites.

3.3.2 State-of-the-art on product delivery and gaps

To deliver the NECCTON Oil products, virtual spills will be seeded from probability density function (PDF) built by means of a new “hot spot” database composed of more than 500,000 Sentinel-1 images 2014–2019 (Dong et al., 2022). To date, there was not enough statistics to cover the whole Mediterranean basin by virtual spills. So, this gap will be bridged. Importantly, the oil drift will be forced by the latest the Copernicus Marine Service reanalyses. Finally, the two types of probability maps will be delivered, one at the sea surface and one on the coastlines, which meet the requirements of multisectoral users.

3.3.3 How NECCTON will innovate the product and fill the gap

To map hazards in the Mediterranean, the stochastic MEDSLIK-II simulations will be launched on a cluster machine in batch mode. New software will be developed to optimize the performance. The statistics obtained will be post-processed and interpreted to get new practical outcomes in accordance with the user requirements. These requirements include for instance facilitation of coastal services, informational support of marine conservation and biodiversity, development of innovative web-based platforms, enhancing the adaptation to climate change, reinforcement of the safety during natural hazard events and extremes, consultancy on policies and ocean governance, supporting the sustainability of the natural resource and energy sector, trade and marine navigation service, and supply of marine food.

3.3.4 Observational data available for product calibration/assimilation/validation

All available observations of oil spills in the Mediterranean Sea fit the problem of product calibration/assimilation/validation. Such kind of data is typically provided by competent authorities as the Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea (REMPEC); Centre de Documentation, de Recherche et d'expérimentation sur les pollutions accidentelles des Eaux (CEDRE); or European Maritime Safety Agency (EMSA). The data often includes the satellite-derived Synthetic Aperture Radar (SAR) and/or optical images, overflight polygons, Bonn Agreement Oil Appearance Codes, and oil beaching protocols. Additionally, we use data published in scientific literature.

3.3.5 Expected users' uptake

In general, the NECCTON products related to oil pollution will be used for the contingency planning and resource management during real oil spill accidents. They also help to guide oil spill monitoring and ecotoxicological sampling.

3.3.6 List of co-products, sub-variables and metadata in the data-files for this product

Co-product ID	**Co-product in bold and green shade**
	Sub-variable in bold and italic
22.1	**Oil**
Sub-variable name [unit]	***Oil spill hazard at sea surface*** [unitless]
Description	
Long name	Hazard at sea surface from oil spill and dispersal
Short name	OIL-HAZ-SUR
Standard_name	Hazard_index_from_oil_spill_at_sea_water_surface

Co-product ID	**Co-product in bold and green shade**
	Sub-variable in bold and italic
22.2	**Oil**
Sub-variable name [unit]	***Oil spill hazard on coastline*** [unitless]
Description	
Long name	Hazard on coastline from oil spill and dispersal
Short name	OIL-HAZ-CST
Standard_name	Hazard_index_from_oil_spill_at_sea_water_coastline

3.4 Product POPs

3.4.0 Introduction

Persistent Organic Pollutants (POPs) are chemical compounds which (1) have a long effective environmental lifetime, (2) are bioaccumulative, (3) and have adverse effects on humans and ecosystems (e.g. toxic, carcinogenic, endocrine). Within the marine ecosystems, these compounds can

persist for extended periods and accumulate in organisms, posing significant threats to both wildlife and human health. POPs include a wide range of synthetic chemicals, such as pesticides, pharmaceuticals, plasticizers, coatings, and even some unintentional byproducts of industrial processes. Their ability to persist in the environment stems from their resistance to degradation under natural conditions. Their ability for bioaccumulation in organisms and subsequent biomagnification along the food chain is associated with high K_{OW} values. Furthermore, bioaccumulation can increase the lifetime as for example the molecules are protected from photolysis. Strictly speaking, POPs refer to those chemicals regulated under the UN Stockholm convention while new chemicals that are not yet regulated in this way are referred to as Contaminants of Emerging Concern (CECs). The amount of CECs has been increasing exponentially over the last decades. Consequently, gaining a deeper understanding of the dynamics of POPs within the ocean and the marine ecosystem is imperative for effective environmental management and regulations. Additionally, the historical use of these chemicals means that legacy POPs continue to cycle through the environment, compounding the challenges posed by primary emissions.

3.4.1 User feedback and requirements

About 33% of respondents to the survey (73 persons) declared an interest in POP related products. Additionally, endocrine disruptors were named explicitly as a specific group of POPs by participants. More than half (55%) of respondents stated an interest in cumulative effects which, besides looking at the interaction of different stressors, is also relevant concerning the adverse effects of mixtures of multiple POPs. More than half, 59% of interested respondents (43 persons) identified as being from the sector 'academic or research institution'. The second largest group with 23% (17 persons) identified as 'private company' or 'consultancy'. Most of the stakeholders work at regional (68%) or national (44%) scale, but also at global (36%) and local (32%) scale. In the free text part of the survey, respondents working on the local and national scale noted their interest in higher resolutions in coastal areas. More in general, the spatial resolution of interest is in the range of few kilometres (from 1-2 km to less than 20 km), while the temporal resolution is expected to be monthly or seasonal.

3.4.2 State-of-the-art on product delivery and gaps

Currently, the Copernicus Marine Service lacks products dealing with POPs. Likewise, such kind of operational product is not available worldwide, to the best of our knowledge. The development of new products related to POPs will create new opportunities to assess the state of regional European seas and the Arctic Ocean regarding pollution and bioaccumulation. The products will include different groups of POPs in seawater, organic particles, and marine biota.

3.4.3 How NECCTON will innovate the product and fill the gap

We will implement chemical mechanisms for selected POPs (Mikheeva et al., 2022) into a marine biogeochemical modelling framework (Bieser et al., 2023). Using a novel unstructured grid model we will be able to deliver POP concentrations in water, organic particles, and marine biota with an increased spatial resolution in the coastal zone (Logemann et al., 2022).

3.4.4 Observational data available for product calibration/assimilation/validation

A compilation of measurement data on POP concentration in air, water, sediment, and biota needs to be created based on publicly available data. For certain POPs, sparse observational data availability can pose a major obstacle for the validation of marine chemistry transport models.

3.4.5 Expected users' uptake

There is a wide range of possible use cases of publicly available data on the distribution of POPs in the ocean. For instance, results will support the implementation of Stockholm Convention on Persistent Organic Pollutants and different kind of studies on water quality, wildlife exposure and bioaccumulation, as well as human exposure.

3.4.6 List of co-products, sub-variables and metadata in the data-files for this product

Co-product ID	**Co-product in bold and green shade**
	Sub-variable in bold and italic
20.1	**POPs**
Sub-variable name [unit]	***PCB 189*** [nmol m^{-3}]
Description	
Long name	Polychlorinated Biphenylester
Short name	PCB189_aq
Standard_name	mole_concentration_of_PCB189_dissolved_in_water
Sub-variable name [unit]	***dissolved PCB 153*** [nmol m^{-3}]
Description	
Long name	Polychlorinated biphenylester congener 153 dissolved in water
Short name	PCB153_aq
Standard_name	mole_concentration_of_PCB153_dissolved_in_water
Sub-variable name [unit]	***dissolved PCB 138*** [nmol m^{-3}]
Description	
Long name	Polychlorinated biphenylester congener 158 dissolved in water
Short name	PCB138_aq
Standard_name	mole_concentration_of_PCB138_dissolved_in_water
Sub-variable name [unit]	***dissolved PCB 118*** [nmol m^{-3}]
Description	
Long name	Polychlorinated biphenylester congener 118 dissolved in water
Short name	PCB118_aq
Standard_name	mole_concentration_of_PCB118_dissolved_in_water
Sub-variable name [unit]	***dissolved PCB 28*** [nmol m^{-3}]
Description	
Long name	Polychlorinated biphenylester congener 28 dissolved in water

Short name	PCB28_aq
Standard_name	mole_concentration_of_PCB28_dissolved_in_water
Sub-variable name [unit]	***particulate PCB 189*** [nmol mgC^{-1}]
Description	
Long name	Polychlorinated Biphenylester
Short name	PCB189_pom
Standard_name	mole_concentration_of_PCB189_on_particulate_organic_matter_in_water
Sub-variable name [unit]	***particulate PCB 153*** [nmol m^{-3}]
Description	
Long name	Polychlorinated biphenylester congener 153 on particulate organic matter
Short name	PCB153_pom
Standard_name	mole_concentration_of_PCB153_on_particulate_organic_matter_in_water
Sub-variable name [unit]	***particulate PCB 138*** [nmol m^{-3}]
Description	
Long name	Polychlorinated biphenylester congener 158 on particulate organic matter
Short name	PCB138_pom
Standard_name	mole_concentration_of_PCB138_on_particulate_organic_matter_in_water
Sub-variable name [unit]	***particulate PCB 118*** [nmol m^{-3}]
Description	
Long name	Polychlorinated biphenylester congener 118 on particulate organic matter
Short name	PCB118_pom
Standard_name	mole_concentration_of_PCB118_on_particulate_organic_matter_in_water
Sub-variable name [unit]	***particulate PCB 28*** [nmol m^{-3}]
Description	
Long name	Polychlorinated biphenylester congener 28 on particulate organic matter
Short name	PCB28_pom
Standard_name	mole_concentration_of_PCB28_on_particulate_organic_matter_in_water
Sub-variable name [unit]	***particulate organic matter*** [mgC m^{-3}]
Description	

Long name	Particulate organic matter
Short name	POM
Standard_name	mass_concentration_of_particulate_organic_matter_expressed_as_carbon_in_sea _in_water

Co-product ID	**Co-product in bold and green shade**
	Sub-variable in bold and italic
20.2	**POP**
Sub-variable name [unit]	***Sum of all modelled dissolved PFAS*** [nmol m^{-3}]
Description	
Long name	Sum of all modelled dissolved PFAS
Short name	PFAS
Standard_name	mole_concentration_of_PFAS_dissolved_in_water
Sub-variable name [unit]	***dissolved perfluoroctanacid*** [nmol m^{-3}]
Description	
Long name	dissolved perfluoroctanacid
Short name	PFOA_d
Standard_name	mole_concentration_of_PFOA_dissolved_in_water
Sub-variable name [unit]	***dissolved perfluoroctansulfonicacid*** [nmol m^{-3}]
Description	
Long name	dissolved perfluoroctansulfonicacid
Short name	PFOS_d
Standard_name	mole_concentration_of_PFOS_dissolved_in_water
Sub-variable name [unit]	***Sum of all modelled dissolved PFAS*** [nmol m^{-3}]
Description	
Long name	Sum of all modelled dissolved PFAS
Short name	PFAS_d
Standard_name	mole_concentration_of_PFAS_dissolved_in_water
Sub-variable name [unit]	***Particulate perfluoroctanacid*** [nmol m^{-3}]
Description	
Long name	dissolved perfluoroctanacid
Short name	PFOA_pom
Standard_name	mole_concentration_of_PFOA_on_particulate_organic_matter_in_water
Sub-variable name [unit]	***Sum of all modelled particulate PFAS*** [nmol m^{-3}]
Description	
Long name	Sum of all modelled particulate PFAS

Short name	PFAS_pom
Standard_name	mole_concentration_of_PFAS_on_particulate_organic_matter_in_water
Sub-variable name [unit]	***Particulate organic matter*** [mgC m^{-3}]
Description	
Long name	Particulate organic matter
Short name	POM
Standard_name	mass_concentration_of_particulate_organic_matter_ expressed_as_carbon_in_sea_water

Co-product ID	**Co-product in bold and green shade**
	Sub-variable in bold and italic
20.3	**POP**
Sub-variable name [unit]	***Particulate organo phosphate esters*** [ng m^{-3}]
Description	
Long name	Particulate organophosphate esters
Short name	OPE_pom
Standard_name	mass_concentration_of_OPE_on_particulate_in_sea_water
Sub-variable name [unit]	***Dissolved organophosphate*** [ng m^{-3}]
Description	
Long name	Dissolved organophosphate esters
Short name	OPE_dis
Standard_name	mass_concentration_of_OPE_dissolved_in_sea_water
Sub-variable name [unit]	***Organo phosphate Aerosol esters*** [ng m^{-3}]
Description	
Long name	Aerosol organophosphate esters
Short name	OPE_aer
Standard_name	mass_concentration_of_OPE_on_aerosol_in_air
Sub-variable name [unit]	***Vapor Organo phosphate esters*** [ng m^{-3}]
Description	
Long name	Vapor organophosphate esters
Short name	OPE_vap
Standard_name	mass_concentration_of_OPE_in_vapor_air

3.5 Product Fisheries pressure

3.5.0 Introduction

Bottom trawl fisheries have long been regarded as the major threat to benthic ecosystem functions since there is no equivalent human physical disturbance on the sea floor in terms of spatial and temporal extents (Jennings and Kaiser, 1998; Thrush and Dayton, 2002; Crowder et al., 2008). While there is ample evidence of fisheries impacts on organisms themselves (Jones, 1992; Kaiser et al., 2002; Sciberras et al., 2018), more comprehensive views on ecosystem-wide damages have been advocated so that the burden of proof becomes a stronger management incentive (Dayton, 1998; Agardy, 2000). Nowadays, European waters are among the most documented in terms of vulnerability to bottom trawling impact, but evaluations still remain to be done in some areas. We will provide such an evaluation for the northwest shelf of the Black Sea.

3.5.1 User feedback and requirements

60% of survey respondents declared that aspects related to fisheries (e.g., fisheries, overfishing, harmful fishing gears) are the main threats of seas and oceans. These stakeholders are from 25 different countries, with the most represented being Italy (10%), Indonesia (7%), France, (6%), Norway (5%), United Kingdom (4%), and Spain (4%). The respondents interested in fishery products are from the following sectors: “Coastal services” (45%), “Climate and Adaptation” (59%), “Policies, Ocean Governance & Mitigation” (38%), “Marine food” (30%), “Ocean Health” (40%), “Extremes, Hazards & Safety” (25%), “Polar Environment Monitoring” (13%), “Trade & Marine Navigation” (9%), “Natural Resources & Energy” (29%), and “Education, Public Health & Recreation” (16%). Most of the stakeholders work at regional (65%) or national (51%) scale, but also at global (30%) and local (35%) scale. Stakeholders are interested in the Copernicus products to conduct scientific research and analysis (90%) to assess and monitor the health of marine ecosystems (62%), develop conservation and management strategies (47%), inform policy and decision-making processes (42%), and to support educational or awareness initiatives (30%). The required temporal resolution for this product is seasonal-annual, and the desired spatial resolution is from 1-2 km to less than 20 km, with some stakeholders highlighting a general need for “good” (high) spatial resolution at coastal sites.

3.5.2 State-of-the-art on product delivery and gaps

Currently, the Copernicus Marine Service does not provide data products related to sea floor functional vulnerability whereas such data are highly demanded by managers. More in general, to the best of our knowledge, no operational products of this kind are available worldwide. Therefore, the information provided with fishery related product is highly innovative.

3.5.3 How NECCTON will innovate the product and fill the gap

Both abiotic and biotic components are impacted by bottom fisheries. We will use a modelling approach developed by De Borger et al. (2021) to assess the effects of increasing trawling frequency on sea floor early diagenesis. Regarding biotic aspects, we will consider two aspects of benthic species communities: vulnerability and ecosystem functions. Following the depletion-recovery approach (Pitcher et al., 2017), we will make spatial predictions on potential effects of bottom trawling on community recoverability according to trawling frequency. The procedure will also be applied for

specific functions as species community subsets and overall community functional diversity as detailed in Beauchard et al. (2023). Most of the methodology has been developed within the ICES Working Group on Bottom Fishing Impact and Trade-offs that is currently benefiting improvements (ICES, 2022).

3.5.4 Observational data available for product calibration/assimilation/validation

We will use data from relatively recent benthic surveys of the Black Sea northwest shelf (2008-2017) and benthic species trait data (Beauchard et al., 2021; Beauchard et al., 2023). Key aspects in species community response to bottom trawling include life span as a proxy for recoverability following trawl disturbance (Hiddink et al., 2017; Rijnsdorp et al., 2018) and sediment burrowing depth to express exposure to fishing gear.

3.5.5 Expected users' uptake

From a biological conservation/protection perspective, the data product will inform on areas where the benthic fauna might be most at risk of extirpation by bottom fisheries. More specifically, abiotic and biotic responses to trawling will indicate where sea floor functions will be the most altered. Such predictions can be considered highly valuable as part of the implementation of marine protected areas.

3.5.6 List of co-products, sub-variables and metadata in the data-files for this product

Co-product ID	**Co-product in bold and green shade**
	Sub-variable in bold and italic
23	**Fisheries pressure**
Sub-variable name [unit]	***Faunal depletion*** [%]
Description	
Long name	Bottom trawling impact on benthic fauna
Short name	ImpBenthFau
Standard_name	Impacted_benthic_fauna_due_to_trawling
Sub-variable name [unit]	***Bioturbation potential*** [%]
Description	
Long name	Bottom trawling impact on bioturbation potential
Short name	ImpBiotuPot
Standard_name	Impacted_bioturbation_potential_due_to_trawling
Sub-variable name [unit]	***Bioirrigation potential*** [%]
Description	
Long name	Bottom trawling impact on bioirrigation potential
Short name	ImpBioirPot
Standard_name	Impacted_bioirrigation_potential_due_to_trawling
Sub-variable name [unit]	***Benthic functional diversity*** [%]

Description	
Long name	Bottom trawling impact on benthic functional diversity
Short name	ImpBenthFD
Standard_name	Impacted_benthic_functional_diversity_due_to_trawling

3.6 Product Climate change stressor index

3.6.0 Introduction

Marine ecosystems are currently facing the pressure of multiple climate-related stressors and their impact is projected to increase in the future due to climate change. Climate-related stressors arise directly from climate change in the marine environment, hence from warming, acidification and deoxygenation. Methods for the estimation of stressors in marine species are well developed but their full impact is seldom adequately harnessed as impact studies are generally confined to scientific and grey literature and/or single stressors are considered in isolation.

3.6.1 User feedback and requirements

60.2% (124 people) of survey respondents declared to be interested in climate change stressor indexes. These stakeholders are from 59 different countries, with the most represented being Italy (11.7%), Indonesia (7.5%), Norway (5.0%), Spain (5.0%) and China (4.2%), they work mostly for Academic or research institutions (66.1%), government or administrative bodies (14.5%), and Private companies (13.7%) mainly in the fields of Marine Conservation & Biodiversity (65.3%), Science & Innovation (49.2%), Coastal Services (48.4%), Policies, Ocean Governance & Mitigation (32.3%). Note that multiple answers are possible, so the total doesn't necessarily sum up to 100%. For this product, the required temporal resolution is seasonal-annual, and the desired spatial resolution is from 1-2 km to less than 20 km, with some stakeholders highlighting a general need for "good" (high) spatial resolution at coastal sites.

3.6.2 State-of-the-art on product delivery and gaps

Currently the Copernicus Marine Service lacks products mapping present and projected multiple species-specific stressors. More in general, to the best of our knowledge no operational products of this kind are available worldwide. While products mapping climate-related stressors are present, these do not allow users to readily infer habitat suitability which is species-specific. The only product mapping thermal suitability in fish (C3S_427.3.3.4_202106_Thermal-Suitability-for-Fish-Species-Habitat_User_Guide_v1) only considers average thermal range and doesn't currently accept requests.

3.6.3 How NECCTON will innovate the product and fill the gap

Multiple environmental climate-related stressor indexes for the North Western European Shelf region that will be calculated and mapped for both present and future periods and for a number of relevant target species. These will inform about present and projected habitat viability.

Along with the stressor mapping the software package used to produce it will be made available so that users will be able to apply the multi-stressor analysis for different species and on different geographical domains. The single stressor indexes will consider both changes in average values and extreme events. The climate-related stressors that will be considered are:

1. rising average temperature and declining average oxygen, combined in the Aerobic Growth Index (AGI, Clarke et al., 2021, Morée et al., 2023),
2. marine heat waves hazard (Galli et al., 2017),
3. hypoxic and anoxic events (Devlin et al. 2022),
4. declining aragonite and calcite saturation.

AGI and the heat wave metric are species-specific, while hypoxia and aragonite saturation are not. The species or species assemblages, suggested by stakeholders during the product co-design meeting, for which stressor mapping will be initially produced are: Herring (*Clupea harengus)*, Cod (*Gadus morhua)*, European Seabass (*Dicentrarchus labrax*), Seabream (*Sparus aurata*), Atlantic Mussel (*Mytilus edulis*), Seaweeds (various species), and Cold Water Corals (various species).

3.6.4 Observational data available for product calibration/assimilation/validation

As this task will collate already existing knowledge the data requirements are moderate, consisting in parameter values for species ecological ranges, in particular thermal range, depth distribution, low oxygen tolerance, which are typically available from the literature (e.g. Morée et al. 2023) or inferable from current distribution. This product will utilise environmental variables from climate models available from the Copernicus Climate Change Service (Copernicus Climate Change Service 2020).

3.6.5 Expected users' uptake

We expect the stressor index products will be useful for stakeholders interested in assessing present and future marine species distribution for the purpose of mapping present and projected viability of commercial activities such as fisheries and aquaculture, for marine protected areas planning, and to assess the impact of marine infrastructure deployment, such as off-shore wind farms and oil and gas extraction.

3.6.6 List of co-products, sub-variables and metadata in the data-files for this product

Co-product ID	**Co-product in bold and green shade**
	Sub-variable in bold and italic
24	**Climate change Stressor**
Sub-variable name [unit]	***Aerobic growth index herring*** [unitless]
Description	
Long name	Aerobic growth index for Clupea harengus in seawater
Short name	AGI_herring
Standard_name	aerobic_growth_index_clupea_harengus
Sub-variable name [unit]	***Aerobic growth index cod*** [unitless]
Description	
Long name	Aerobic growth index for Gadus morhua in seawater
Short name	AGI_cod
Standard_name	aerobic_growth_index_gadus_morhua

Sub-variable name [unit]	***Aerobic growth index seabass*** [unitless]
Description	
Long name	Aerobic growth index for Dicentrarchus labrax in seawater
Short name	AGI_seabass
Standard_name	aerobic_growth_index_dicentrarchus_labrax
Sub-variable name [unit]	***Aerobic growth index seabream*** [unitless]
Description	
Long name	Aerobic growth index for Sparus aurata in seawater
Short name	AGI_seabream
Standard_name	aerobic_growth_index_sparus_aurata
Sub-variable name [unit]	***Aerobic growth index atlantic mussel*** [unitless]
Description	
Long name	Aerobic growth index for Mytilus edulis in seawater
Short name	AGI_mussel
Standard_name	aerobic_growth_index_mytilus_edulis
Sub-variable name [unit]	***Aerobic growth index seaweeds*** [unitless]
Description	
Long name	Aerobic growth index for seaweeds in seawater
Short name	AGI_seaweed
Standard_name	aerobic_growth_index_seaweeds
Sub-variable name [unit]	***Aerobic growth index cold water corals*** [unitless]
Description	
Long name	aerobic_growth_index for cold water corals in seawater
Short name	AGI_cwc
Standard_name	aerobic_growth_index_cold_water_corals
Sub-variable name [unit]	***Heat wave hazard index herring*** [unitless]
Description	
Long name	Heat wave hazard index for Clupea harengus in seawater
Short name	HWHI_herring
Standard_name	heat_wave_hazard_index_clupea_harengus
Sub-variable name [unit]	***Heat wave hazard index cod*** [unitless]
Description	
Long name	Heat wave hazard index for Gadus morhua in seawater
Short name	HWHI_cod

Standard_name	heat_wave_hazard_index_ gadus_morhua
Sub-variable name [unit]	***Heat wave hazard index seabass*** [unitless]
Description	
Long name	Heat wave hazard index for Dicentrarchus labrax in seawater
Short name	HWHI_seabass
Standard_name	heat_wave_hazard_index_dicentrarchus_labrax
Sub-variable name [unit]	***Heat wave hazard index seabream*** [unitless]
Description	
Long name	Heat wave hazard index for Sparus aurata in seawater
Short name	HWHI_seabream
Standard_name	heat_wave_hazard_index_sparus_aurata
Sub-variable name [unit]	***Heat wave hazard index atlantic mussel*** [unitless]
Description	
Long name	Heat wave hazard index for Mytilus edulis in seawater
Short name	HWHI_mussel
Standard_name	heat_wave_hazard_index_mytilus_edulis
Sub-variable name [unit]	***Heat wave hazard index seaweeds*** [unitless]
Description	
Long name	Heat wave hazard index for seaweeds in seawater
Short name	HWHI_seaweeds
Standard_name	heat_wave_hazard_index_seaweeds
Sub-variable name [unit]	***Heat wave hazard index cold water corals*** [unitless]
Description	
Long name	Heat wave hazard index for cold_water corals in_seawater
Short name	HWHI_cold_water_corals
Standard_name	heat_wave_hazard_index_cold_water_corals
Sub-variable name [unit]	***Hypoxia index*** [unitless]
Description	
Long name	Hypoxia index in seawater
Short name	HI
Standard_name	hypoxia_index
Sub-variable name [unit]	***Aragonite saturation*** [unitless]
Description	
Long name	Aragonite saturation in seawater

Short name	om_ar
Standard_name	aragonite_saturation

3.7 Product multi-stressor index

3.7.0 Introduction

Species niches are multi-dimensional and result from processes at multiple spatial and temporal scales; for example, an environment may seem viable if annual average temperature is within a species range, but this may be negated if, e.g., harmful marine heat waves and/or hypoxia happen frequently enough to prevent populations to recover from their effects. This, and other combined effects must be considered when mapping present and projected species habitat viability. Environmental stressors are projected to substantially intensify due to climate change. Robust projections of future species distribution depend on assessing the spatio-temporal distribution of multiple environmental stressors and on their integration into multi-stressor metrics.

3.7.1 User feedback and requirements

37.9% of survey respondents (78 people) declared to be interested in multi-stressor indexes. These stakeholders are based in multiple countries, with the most represented being Italy 15.8% (12 people), Indonesia 5.3% (4 people), and Spain, Algeria, United Kingdom, Norway and United States (all 3.9%, 3 people each). They work mainly for Academic or research institutions 62.8% (49 people), government or administrative bodies 14.1% (11 people), Private companies 14.1% (11 people) or consultancies 11.5% (9 people). They mainly work in the fields of Marine Conservation & Biodiversity 73.1% (57 people), Science & Innovation 53.8% (42 people), Coastal Services 50.0% (39 people), Policies, Ocean Governance & Mitigation 38.5% (30 people). Note that multiple answers are possible so the total doesn't necessarily sum up to 100%. Also 55.1% of respondents (118 people) declared to be interested cumulative effect assessment, but of those 81.7% (94 people) don't currently use any specific tool for cumulative effect assessment, indicating a need for this specific product. For this product, the required temporal resolution is seasonal-annual, and the desired spatial resolution is from 1-2 to less than 20 km.

3.7.2 State-of-the-art on product delivery and gaps

At present the Copernicus Marine and Climate Change services does not provide mapped products for species-specific multi-environmental-stressor indices. More in general, to the best of our knowledge no operational products of this kind are available worldwide.

3.7.3 How NECCTON will innovate the product and fill the gap

The single environmental stressor indices from NECCTON product 25 will be combined in a single multi-stressor index using the Combined Effect Assessment methodology (CEA, Halpern et al., 2008, Goodsir et al. 2015). The result will be mapped for present and projected periods for the North Western European Shelf region. The software package used for stressor index integration and mapping will also be made available so that users will be able to expand the analysis to different species and geographical domains with minimal effort.

3.7.4 Observational data available for product calibration/assimilation/validation

Being based on the output of product 25 and on already established methods, the data requirements for this product are minimal. Current species distribution data will be used for validation and future projection will use environmental variables fields from available Copernicus products (Copernicus Climate Change Service 2020).

3.7.5 Expected users' uptake

This product will be useful for stakeholders interested in present and projected species distribution and on mapping suitability for commercial activities, like fisheries and aquaculture, for marine protection planning, and for impact assessment of other marine activities like offshore wind farms and oil and gas extraction.

3.7.6 List of co-products, sub-variables and metadata in the data-files for this product

Co-product ID	**Co-product in bold and green shade**
	Sub-variable in bold and italic
25	**Multi stressors**
Sub-variable name [unit]	***Multi stressor index herring*** [unitless]
Description	
Long name	Multi stressor index for Clupea harengus in seawater
Short name	MSI_herring
Standard_name	multi_stressor_index_clupea_harengus
Sub-variable name [unit]	***Multi stressor index cod*** [unitless]
Description	
Long name	Multi stressor index for Gadus morhua in seawater
Short name	MSI_cod
Standard_name	multi_stressor_index_gadus_morhua
Sub-variable name [unit]	***Multi stressor index seabass*** [unitless]
Description	
Long name	Multi stressor index for Dicentrarchus labrax in seawater
Short name	MSI_seabass
Standard_name	multi_stressor_index_dicentrarchus
Sub-variable name [unit]	***Multi stressor index seabream*** [unitless]
Description	
Long name	Multi stressor index for Sparus aurata in seawater
Short name	MSI_seabream
Standard_name	multi_stressor_index_sparus_aurata
Sub-variable name [unit]	***Multi stressor index atlantic mussel*** [unitless]
Description	

Long name	Multi stressor index for Mytilus edulis in seawater
Short name	MSI_mussel
Standard_name	multi_stressor_index_mytilus_edulis
Sub-variable name [unit]	***Multi stressor index seaweeds*** [unitless]
Description	
Long name	Multi stressor index for seaweeds in seawater
Short name	MSI_seaweed
Standard_name	multi_stressor_index_seaweeds
Sub-variable name [unit]	***Multi stressor index cold water corals*** [unitless]
Description	
Long name	Multi stressor index for cold water corals in seawater
Short name	MSI_cwc
Standard_name	multi_stressor_index_cold_water_corals

4. Datasets description

The products described in Section 3 will be delivered in the form of "datasets" (see the definition in the glossary). All the 12 datasets containing the products developed by WP8 are described in the following sub-sections.

4.1 H30 – Mercury in the Mediterranean Sea

ID dataset	H30
Products names (product IDs)	Mercury (21.1)
Name sub-variables	Oxidized mercury, Elemental mercury, Monomethylmercury, Dimethylmercury, MMHg in phytoplankton, MMHg to C in phytoplankton,MMHg in zooplankton, MMHg to C in zooplankton
Geographical coverage	Mediterranean Sea
Horizontal resolution	1/16° (about 6 km)
Vertical resolution	72 levels
Time period	2005-2021
Temporal resolution	monthly
Data-file(s):	neccton-ogs_mod_med_mercury-HgII_hind_6km_P1M-m_mf_mmYYYY, neccton-ogs_mod_med_mercury-Hg0_hind_6km_P1M-m_mf_mmYYYY, neccton-ogs_mod_med_mercury-MMHg_hind_6km_P1M-m_mf_mmYYYY, neccton-ogs_mod_med_mercury-DMHg_hind_6km_P1M-m_mf_mmYYYY, neccton-ogs_mod_med_mercury-MMHg-Phy_hind_6km_P1M-m_mf_mmYYYY,

	neccton-ogs_mod_med_mercury-MMHg-C-Phy_hind_6km_P1M-m_mf_mmYYYY, neccton-ogs_mod_med_mercury-MMHg-Zoo_hind_6km_ P1M-m_mf_mmYYYY, neccton-ogs_mod_med_mercury-MMHg-C-Zoo_hind_6km_ P1M-m_mf_mmYYYY
Expected total, max size of datafile(s) [Gb]:	300 Gb
Format	gridded, NetCDF
Partner producer and contact	OGS, Ginevra Rosati, grosati@ogs.it
Datasets used for calibration/validation/assimilation	dataset including all available field observations – also unpublished- from 1997 to 2015, which is being compiled in this WP.
Method	Coupled OGSTM-BFM-Hg (Rosati et al. 2022) forced by ECMWF ERA INTERIM meteo, CMCC-CM model boundary, CIRCE river runoff and PERSEUS river load of nutrients

4.2 H31 – Plastics in the Mediterranean Sea

ID dataset	H31
Products names (product IDs)	plastic (19.1)
Name sub-variables	Microplastics >0.3mm surface, Microplastics 0.3-0.4 mm Surface, Microplastics 0.4-0.6 mm Surface, Microplastics 0.6-1.5 mm Surface, Microplastics 1.5-2.5 mm Surface, Microplastics 2.5-5 mm Surface, Microplastics >0.3mm Water column, Macroplastics 5-20 mm, Macroplastics 20-200 mm, Macroplastics >200 mm
Geographical coverage	Mediterranean Sea
Horizontal resolution	1/10° 10 km
Vertical resolution	to be defined
Time period	2010-2020
Temporal resolution	Seasonal, monthly climatology
Data-file(s):	neccton-minds_mod_med_microplastic_srf_hind_10km_ P1M-m_mf, neccton-minds_mod_med_macroplastic_srf_hind_10km_P1M-m_mf, neccton-minds_mod_med_microplastic_water_hind_10km_P1M-m_mf
Expected total, max size of datafile(s) [Gb]:	20 Gb
Format	gridded, NetCDF
Partner producer and contact	MINDS, George Triantafyllou, gt@hcmr.gr
Datasets used for calibration/validation/assimilation	A dataset including all available field observations from databases (EMODNET, EEA, NOAA) and various publications is currently compiled in this WP.
Method	Coupled hydrodynamic/biogeochemical POM-ERSEM (Kalaroni et al., 2021) with Lagrangian model for plastics (Tsiaras et al., 2021), forced by POSEIDON (www.hcmr.gr) meteo, Climatology (MODB, MEDATLAS) boundary conditions/Gibraltar, Ludwig et al., 2009 river inputs

4.3 H32 – Oil in the Mediterranean Sea

ID dataset	H32
Products names (product IDs)	oil (22)
Name sub-variables	oil_haz_srf * oil_haz_cst *
Geographical coverage	Mediterranean Sea
Horizontal resolution	30 arch sec, ~800m *
Vertical resolution	N/A
Time period	2020–2021 *
Temporal resolution	Daily
Data-file(s):	neccton-cmcc_mod_med_oil-haz_srf_hind_800m_P1D-m_mf_ddmmYYYY * neccton-cmcc_mod_med_oil-haz_ cst_hind_800m_P1D-m_mf_ddmmYYYY *
Expected total, max size of datafile(s) [Gb]:	100 Gb *
Format	gridded, NetCDF
Partner producer and contact	CMCC, Svitlana Liubartseva, svitlana.liubartseva@cmcc.it
Datasets used for calibration/validation/assimilation	Overflights of MT *Haven* oil spill (April 1991, Genoa, Italy) provided by METEO FRANCE
Method	Stochastic oil spill modelling with MEDSLIK-II (De Dominicis et al., 2013)
**provisional*	

4.4 H33 – Plastics in the North-West European Shelf

ID dataset	H33
Products names (product IDs)	plastic (19.2)
Name sub-variables	Microplastics > 0.3mm Surface, Microplastics 0.3-0.4mm Surface, Microplastics 0.4mm – 0.6mm Surface, Microplastics 0.6-1.5mm Surface, Microplastics 1.5-2.5mm Surface, Microplastics 2.5-5mm Surface, Microplastics > 0.3mm Water Column, Microplastics 0.3-0.4mm Water Column, Microplastics 0.4mm – 0.6mm Water Column, Microplastics 0.6-1.5mm Water Column, Microplastics 1.5-2.5mm Water Column, Microplastics 2.5-5 mm Water Column
Geographical coverage	North-West European Shelf
Horizontal resolution	1/12° 9km
Vertical resolution	To be defined
Time period	2007-2021
Temporal resolution	Weekly
Data-file(s):	neccton_uu_plastic-microplastic_srf_nws_hind_9km_ P1W-m_mf, neccton_uu_plastic-microplastic_water_nws_hind_9km_ P1W-m_mf
Expected total, max size of datafile(s) [Gb]:	e.g.: 50 Gb

Format	gridded, NetCDF
Partner producer and contact	Utrecht University, Michael Denes, m.c.denes@uu.nl
Datasets used for calibration/validation/assimilation	A dataset including all available field observations from databases and various publications.
Method	Refined version of a Lagrangian model for plastics (Delandmeter, & van Sebille, 2019), using coastline inputs (Jambeck et al., 2015), river inputs (Meijer et al., 2021), and fisheries inputs (Kroodsma et al., 2018).

4.5 H34 – Plastics in the Arctic Sea

ID dataset	H34
Products names (product IDs)	plastic (19.2)
Name sub-variables	To be refined
Geographical coverage	Arctic Sea
Horizontal resolution	1/12° 9km
Vertical resolution	To be defined
Time period	2007-2022
Temporal resolution	Weekly
Data-file(s):	neccton_uu_plastic-microplastic_srf_arc_hind_9km_P1W-m_mf, neccton_uu_ plastic-microplastic_water_arc_hind_9km_P1W-m_mf
Expected total, max size of datafile(s) [Gb]:	e.g.: 50 Gb
Format	gridded, NetCDF
Partner producer and contact	Utrecht University, Michael Denes, m.c.denes@uu.nl
Datasets used for calibration/validation/assimilation	A dataset including all available field observations from databases and various publications.
Method	Refined version of a Lagrangian model for plastics (Delandmeter, & van Sebille, 2019), using coastline inputs (Jambeck et al., 2015), river inputs (Meijer et al., 2021), and fisheries inputs (Kroodsma et al., 2018).

4.6 H35 – Mercury in the Global Ocean

ID dataset	H35
Products names (product IDs)	Mercury (21.2)
Name sub-variables	Dissolved Oxidized mercury, Particle bound inorganic mercury Dissolved elemental mercury, Cinnabar, Dissolved monomethylmercury, Particulate monomethylmercury, Particulate organic matter, Dimethylmercury, HgII in phytoplankton, MMHg in phytoplankton, HgII in phycosphere, MMHg in phycosphere, Phytoplankton, HgII adsorbed onto zooplankton, MMHg adsorbed onto zooplankton, HgII absorbed into zooplankton, MMHg absorbed into zooplankton, Zooplankton, Inorganic mercury in sediment, MMHg in

	sediment, Inorganic mercury bioconcentrated in macrobenthos MMHg bioconcentrated in macrobenthos, Inorganic mercury biomagnified in macrobenthos MMHg biomagnified in macrobenthos, Macrobenthos biomass, Inorganic mercury in fish, MMHg in fish, Inorganic mercury in fish, metyhlmerc MMHg in fish, Fish biomass
Geographical coverage	Global ocean
Horizontal resolution	unstructured grid 7-100 km
Vertical resolution	To be defined
Time period	2010-2020
Temporal resolution	monthly
Data-file(s):	neccton-hereon_mod_glob_mercury-HgII_d_glob_hind_unstr_P1M-m_mf_mmYYYY neccton-hereon_mod_glob_mercury-HgII_p_glob_hind_unstr_P1M-m_mf_mmYYYY neccton-hereon_mod_glob_mercury-Hg0_g_glob_hind_unstr_P1M-m_mf_mmYYYY neccton-hereon_mod_glob_mercury-HgS_glob_hind_unstr_P1M-m_mf_mmYYYY neccton-hereon_mod_glob_mercury-MHg_d_glob_hind_unstr_P1M-m_mf_mmYYYY neccton-hereon_mod_glob_mercury-MHg_p_glob_hind_unstr_P1M-m_mf_mmYYYY neccton-hereon_mod_glob_mercury-DMHg_g_glob_hind_unstr_P1M-m_mf_mmYYYY neccton-hereon_mod_glob_mercury-HgII_PHY_bc_glob_hind_unstr_P1M-m_mf_mmYYYY neccton-hereon_mod_glob_mercury-MMHg_PHY_bc_glob_hind_unstr_P1M-m_mf_mmYYYY neccton-hereon_mod_glob_mercury-HgII_PHYCOS_bc_glob_hind_unstr_P1M-m_mf_mmYYYY neccton-hereon_mod_glob_mercury-MMHg_PHYCOS_bc_glob_hind_unstr_P1M-m_mf_mmYYYY neccton-hereon_mod_glob_mercury-HgII_ZOO_bc_glob_hind_unstr_P1M-m_mf_mmYYYY neccton-hereon_mod_glob_mercury-MMHg_ZOO_bc_glob_hind_unstr_P1M-m_mf_mmYYYY neccton-hereon_mod_glob_mercury-HgII_ZOO_bc_glob_hind_unstr_P1M-m_mf_mmYYYY neccton-hereon_mod_glob_mercury-MMHg_ZOO_bc_glob_hind_unstr_P1M-m_mf_mmYYYY neccton-hereon_mod_glob_mercury-HgII_ZOO_bm_glob_hind_unstr_P1M-m_mf_mmYYYY

	neccton-hereon_mod_glob_mercury-MMHg_ZOO_bm_glob_hind_unstr_P1M-m_mf_mmYYYY neccton-hereon_mod_glob_mercury-HgII_MAC_bc_glob_hind_unstr_P1M-m_mf_mmYYYY neccton-hereon_mod_glob_mercury-MMHg_MAC_bc_glob_hind_unstr_P1M-m_mf_mmYYYY neccton-hereon_mod_glob_mercury-HgII_MAC_bm_glob_hind_unstr_P1M-m_mf_mmYYYY neccton-hereon_mod_glob_mercury-MMHg_MAC_bm_glob_hind_unstr_P1M-m_mf_mmYYYY neccton-hereon_mod_glob_mercury-HgII_FISH_bc_glob_hind_unstr_P1M-m_mf_mmYYYY neccton-hereon_mod_glob_mercury-MMHg_FISH_bc_glob_hind_unstr_P1M-m_mf_mmYYYY neccton-hereon_mod_glob_mercury-HgII_FISH_bm_glob_hind_unstr_P1M-m_mf_mmYYYY neccton-hereon_mod_glob_mercury-MMHg_FISH_bm_glob_hind_unstr_P1M-m_mf_mmYYYY neccton-hereon_mod_glob_mercury-POM_glob_hind_unstr_P1M-m_mf_mmYYYY neccton-hereon_mod_glob_mercury-MACbiomass_glob_hind_unstr_P1M-m_mf_mmYYYY neccton-hereon_mod_glob_mercury-FISHbiomass_glob_hind_unstr_P1M-m_mf_mmYYYY
Expected total, max size of datafile(s) [Gb]:	300 Gb
Format	Gridded, NetCDF
Partner producer and contact	Hereon, Johannes Bieser, johannes.bieser@hereon.de
Datasets used for calibration/validation/assimilation	water, sediment, and biota data collected within the project from on publicly available data.
Method	Bieser et al., 2023

4.7 H37 – POPs (PCB) in the Global Ocean

ID dataset	H37
Products names (product IDs)	POP (21.2)
Name sub-variables	PCB 189, dissolved PCB 153, dissolved PCB 138, dissolved PCB 118, dissolved PCB 28, particulate PCB 189, particulate PCB 153, particulate PCB 138, particulate PCB 118, particulate PCB 28, particulate organic matter
Geographical coverage	Global ocean
Horizontal resolution	unstructured grid 7-100 km

Vertical resolution	To be defined
Time period	2010-2020
Temporal resolution	monthly
Data-file(s):	neccton-hereon_mod_glob_POP-PCB189d_glob_hind_unstr_P1M-m_mf _mmYYYY neccton-hereon_mod_glob_POP-PCB153d_glob_hind_unstr_P1M-m_mf _mmYYYY neccton-hereon_mod_glob_POP-PCB138d_glob_hind_unstr_P1M-m_mf _mmYYYY neccton-hereon_mod_glob_POP-PCB118d_glob_hind_unstr_P1M-m_mf _mmYYYY neccton-hereon_mod_glob_POP-PCB28d_glob_hind_unstr_P1M-m_mf _mmYYYY neccton-hereon_mod_glob_POP-PCB189p_glob_hind_unstr_P1M-m_mf _mmYYYY neccton-hereon_mod_glob_POP-PCB153p_glob_hind_unstr_P1M-m_mf _mmYYYY neccton-hereon_mod_glob_POP-PCB138p_glob_hind_unstr_P1M-m_mf _mmYYYY neccton-hereon_mod_glob_POP-PCB118p_glob_hind_unstr_P1M-m_mf _mmYYYY neccton-hereon_mod_glob_POP-PCB28p_glob_hind_unstr_P1M-m_mf _mmYYYY neccton-hereon_mod_glob_POP-POM_glob_hind_unstr_P1M-m_mf _mmYYYY
Expected total, max size of datafile(s) [Gb]:	300 Gb
Format	Gridded, NetCDF
Partner producer and contact	Hereon, Johannes Bieser, johannes.bieser@hereon.de
Datasets used for calibration/validation/assimilation	water, sediment, and biota data collected within the project from publicly available data.
Method	Coupled 3d numerical hydrodynamic biogeochemical (ECOSMO) model with PFAS transport and transformation. PCB chemistry (Mikheeva et al., 2022) based on the marine modeling framework described in (Bieser et al., 2023).

4.8 H38 – POPs (PFAS) in the Global Ocean

ID dataset	H38
Products names (product IDs)	PFAS (23.2)

Name sub-variables	Total dissolved PFAS, Total particulate PFAS, dissolved perfluoroctanacid, dissolved perfluoroctansulfonicacid, particulate perfluoroctanacid, particulate perfluoroctansulfonicacid, Particulate organic matter
Geographical coverage	Global ocean
Horizontal resolution	unstructured grid 7-100 km
Vertical resolution	To be defined
Time period	2010-2020
Temporal resolution	monthly
Data-file(s):	neccton-hereon_mod_glob_POP-tPFASd_glob_hind_unstr_P1M-m_mf _mmYYYY neccton-hereon_mod_glob_POP-tPFASp_glob_hind_unstr_P1M-m_mf _mmYYYY neccton-hereon_mod_glob_POP- PFOAd_glob_hind_unstr_P1M-m_mf _mmYYYY neccton-hereon_mod_glob_POP- PFOSd_glob_hind_unstr_P1M-m_mf _mmYYYY neccton-hereon_mod_glob_POP- PFOAp_glob_hind_unstr_P1M-m_mf _mmYYYY neccton-hereon_mod_glob_POP- PFOSp_glob_hind_unstr_P1M-m_mf _mmYYYY neccton-hereon_mod_glob_POP-POM_glob_hind_unstr_P1M-m_mf _mmYYYY
Expected total, max size of datafile(s) [Gb]:	300 Gb
Format	Gridded, NetCDF
Partner producer and contact	Hereon, Johannes Bieser, johannes.bieser@hereon.de
Datasets used for calibration/validation/assimilation	water, sediment, and biota data collected within the project from on publicly available data.
Method	Coupled 3d numerical hydrodynamic biogeochemical (ECOSMO) model with PFAS transport and transformation. Emissions based on Simon et al., 2023: https://permalink.aeris-data.fr/POPE and atmospheric deposition from ICON-ART (Thackray et al., 2020; Meza, in prep.).

4.8 H39 – POPs (OPE) in the Global Ocean

ID dataset	H39
Products names (product IDs)	OPE (20.3)
Name sub-variables	OPE concentration in air, OPE concentration in seawater, air-sea exchange flux
Geographical coverage	Global ocean
Horizontal resolution	1° latitude by 1° longitude
Vertical resolution	14 vertical levels
Time period	2010-2020
Temporal resolution	Yearly
Data-file(s):	neccton-hereon_mod_arc_wat_OPE-pom_mmYYYY neccton-hereon_mod_arc_wat_OPE-dis_mmYYYY neccton-hereon_mod_arc_air_OPE-aer_mmYYYY neccton-hereon_mod_arc_air_OPE-vap_mmYYYY
Expected total, max size of datafile(s) [Gb]:	5 Gb
Format	Gridded, NetCDF
Partner producer and contact	Hereon, Zhiyong Xie, Zhiyong.xie@hereon.de
Datasets used for calibration/validation/assimilation	A dataset including all available field observations from databases and various publications.
Method	ChnMETOP a three-dimensional atmospheric transport model coupled with modules simulating POP cycling between various environmental compartments (He et al. 2023, Zhao et al. 2019)

4.9 H42 – Fisheries pressure for the Baltic Sea

ID dataset	H42
Products names (product IDs)	Fisheries pressure (23)
Name sub-variables	Faunal depletion, Bioturbation potential, Bioirrigation potential, Benthic functional diversity
Geographical coverage	Black Sea
Horizontal resolution	0.1° latitude by 0.1° longitude
Vertical resolution	1 level
Time period	2008-2017
Temporal resolution	Unique, averaged over the period 2008-2017
Data-file(s):	neccton-nioz_mod_bs_trawling_impact-benthic_fauna_8km_irr-m_mf, neccton-nioz_mod_bs_trawling_impact-bioturbation_ potential_8km_ irr-m_mf,

	neccton-nioz_mod_bs_trawling_impact-bioirrigation_potential_8km_ irr-m_mf, neccton-nioz_mod_bs_trawling_impact-benthic_functional_diversity_8km_ irr-m_mf
Expected total, max size of datafile(s) [Gb]:	5 Gb
Format	gridded, NetCDF
Partner producer and contact	NIOZ, Karline Soetaert, karline.soetaert@nioz.nl
Datasets used for calibration/validation/assimilation	Existing benthic survey data sets from 2008 to 2017 covering the northwest shelf of the Black Sea
Method	Depletion-recovery approach (Pitcher et al., 2017)

4.10 H43 – Climate change stressor indexes for the North Western European Shelf

ID dataset	H43
Products names (product IDs)	Climate change stressor indexes (24)
Name sub-variables	aerobic_growth_index_*, hypoxia_index, heat_wave_exposure_index_*, aragonite_saturation
Geographical coverage	North Western European Shelf
Horizontal resolution	1/15° latitude by 1/9° longitude (~7 km)
Vertical resolution	51 levels
Time period	2006-2099
Temporal resolution	Yearly
Data-file(s) **:	neccton-pml_mod_nws_clim_str-agi-sp_hind_7km_ P1Y-m_mf_yYYYY* neccton-pml_mod_nws_clim_str-hwhi-sp_hind_7km_ P1Y-m_mf_yYYYY* neccton-pml_mod_nws_clim_str-hi-sp_hind_7km_ P1Y-m_mf_yYYYY* neccton-pml_mod_nws_clim_str-om-arg_hind_7km_ P1Y-m_mf_yYYYY*
Expected total, max size of datafile(s) [Gb]:	50 Gb
Format	gridded, NetCDF
Partner producer and contact	PML, Giovanni Galli, James Clark: jcl@pml.ac.uk
Datasets used for calibration/validation/assimilation	Copernicus Climate Change Service 2020
Method	Aerobic Growth Index (Morée et al. 2023), heat wave hazard Mapping (Galli et al. 2017), hypoxia assessment (Devlin et al. 2023), aragonite saturation.
** for each species sp as listed in Table 3.6.6* *** "YYYY": annual files*	

4.11 H44 – Multi-stressor index for the North Western European Shelf

ID dataset	H44
Products names (product IDs)	Multi-stressor index (25)
Name sub-variables	multi_stressor_index_sp*
Geographical coverage	North Western European Shelf
Horizontal resolution	1/15° latitude by 1/9° longitude (~7 km)
Vertical resolution	51 levels
Time period	2006-2099
Temporal resolution	yearly
Data-file(s):	neccton-pml_mod_nws_multi_str-msi-sp_hind_7km_ P1Y-m_mf _yYYYY
Expected total, max size of datafile(s) [Gb]:	10 Gb
Format	gridded, NetCDF
Partner producer and contact	PML, Giovanni Galli, James Clark: jcl@pml.ac.uk
Datasets used for calibration/validation/assimilation	Copernicus Climate Change Service 2020
Method	Cumulative effect assesment (CEA, Halpern et al., 2008, Goodsir et al., 2015).
** for each species as listed in Table 3.7.6*	

5. Concluding remarks

NECCTON WP8 will deliver to the Copernicus Marine Service the capability to deliver a new generation of Ocean Data Products related to marine pollution and stressors. Such information is crucial to provide a more comprehensive view of the status of marine ecosystems across European and Global Ocean. The novel products delivered by WP8 encompass a wide range of pollutants (mercury, plastic, oil, and different families of POPs) and stressors (bottom trawl fishery, climate change, and multiple stress) in different geographic areas (North-West European Shelf, Mediterranean Sea, Black Sea, and Arctic).

Spatial-temporal distributions of pollutants and hazard indexes from the most advanced modelling tools at the state of the art will be made publicly available, along with the codes to run the models, improving openness, collaboration, and interoperability within the scientific community. Policymakers and other stakeholders from NGOs and private sector will also benefit from the product delivered by WP8. Indeed, as also highlighted by the results of the stakeholders meeting and survey, there is an increasing need for integrating multiple layers of information to protect marine ecosystems and promote sustainability of anthropogenic activities. WP8 products will support a plethora of practical tasks that can be grouped as follows:

a) Marine Spatial Planning – for the management of Marine Protected Areas, “Natura 2000” sites, exclusive economic zones, and aquaculture sites,

b) Impact and Risk Assessment for Marine Ecosystem – on aquaculture, acidification, heat-waves, oil and gas exploitation, marine traffic, cumulative stressors, and pollution
c) Compliance to EU Law and International Treaties – implementation of the Marine Strategy Framework Directive for the good environmental status, Minamata convention for mercury, Stockholm convention on persistent organic pollutants
d) Food Safety and Ecosystem Services – pollutant bioaccumulation and biomagnification in marine food webs

Challenges intrinsically related to the novelty of the WP activities are the timely delivery of all products and the relatively limited number of observations to validate the models compared to other oceanographic variables that are monitored more continuously. With this regard, comprehensive datasets of available field observations are under compilation for each product.

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