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DEC	Websites, patents, filing, etc.	
DEM	Demonstrator	
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CO	Confidential, only for members of the consortium (including the Commission Services)	

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NAUTILOS - New Approach to Underwater Technologies for Innovative, Low-cost Ocean observation is an H2020 project funded under the Future of Seas and Oceans Flagship Initiative, coordinated by the National Research Council of Italy (Consiglio Nazionale delle Ricerche, CNR). It brings together a group of 21 entities from 11 European countries with multidisciplinary expertise ranging from ocean instrumentation development and integration, ocean sensing and sampling instrumentation, data processing, modelling and control, operational oceanography and biology and ecosystems and biogeochemistry such, water and climate change science, technological marine applications and research infrastructures.

NAUTILOS will fill-in marine observation and modelling gaps for chemical, biological and deep ocean physics variables through the development of a new generation of cost-effective sensors and samplers, the integration of the aforementioned technologies within observing platforms and their deployment in large-scale demonstrations in European seas. The fundamental aim of the project will be to complement and expand current European observation tools and services, to obtain a collection of data at a much higher spatial resolution, temporal regularity and length than currently available at the European scale, and to further enable and democratise the monitoring of the marine environment to both traditional and non-traditional data users.

NAUTILOS is one of two projects included in the EU's efforts to support of the European Strategy for Plastics in a Circular Economy by supporting the demonstration of new and innovative technologies to measure the Essential Ocean Variables (EOVs).

More information on the project can be found at: <https://www.nautilus-h2020.eu/>.

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EXECUTIVE SUMMARY

The timely, free and unrestricted exchange of oceanographic observational data is essential for the efficient acquisition, integration and use of ocean observations gathered by the several projects carried out all over the world for a variety of purposes, such as weather forecasts and climate projections, the preservation of wildlife, marine and coastal environmental management etc.

An open and free data policy is highly promoted by the European Commission and its member states for a wide range of environmental data services targeted to a wide range of user communities. Interoperability of data systems has become a priority with the development of FAIR principles¹, *i.e.*, a set of guiding principles to make data **Findable, Accessible, Interoperable, and Re-usable**.

In the past decade, European partners, in close collaboration with international partners, have been playing an active role in the improvement of environmental data standardisation, accessibility and interoperability through several EU projects (*e.g.* Copernicus Marine Service - CMEMS, SeaDataNet, AtlantOS, ODIP and EMODnet), enhancing access to observational data at all stages of the data life cycle and fostering the development of integrated services targeted to research, regulatory and operational users.

In line with these recommendations and agreements, NAUTILOS aims to make accessible and freely available on the internet all the marine data gathered within the project. The NAUTILOS data management policy is committed to make available NAUTILOS data interoperable with other European and Global Ocean data initiatives, and EMODnet with its thematic lots, CMEMS (in particular the INSTAC), SeaDataNet network of NODCs, are the primary stakeholders. NAUTILOS is developing and deploying state of art data management backend infrastructure and tools and these support machine to machine interoperability features to be used by NAUTILOS stakeholder to harvest and use relevant data and products. Furthermore, NAUTILOS data management policy clarifies the roles on the ownership and custodianship of the data, as well as the recommendations on data citation.

Data sharing and dissemination principles:

- Research infrastructures and partners joining the NAUTILOS project support free, open access to data and metadata produced by their facilities and are committed to working towards the implementation of this principle;
- Data and metadata generated during the project will be made available following an open access policy, without any restrictions and available for free to third parties;
- Appropriate controlled dictionaries (CF convention and SeaDataNet vocabularies) are recommended to be used for metadata description;

¹ <https://www.force11.org/group/fairgroup/fairprinciples>

- A metadata catalogue will be accessible on the NAUTILOS portal and data will be made available to facilitate NAUTILOS portfolio to projects and initiatives.

Contribution of data:

- The general responsibility for datasets that have been made available remains within the contributing institution/custodian/data originator;
- The quality assurance of data is the responsibility of the custodian/data originator;
- Data providers are requested to inform of any national policies that may place special conditions on the redistribution of data;
- Data licence is whenever possible CC-BY;
- Metadata shall be provided for each dataset following, as far as possible, agreed standards.

Use of data:

- Data interpretation is solely the responsibility of data user;
- Data sources shall be acknowledged, preferably using a formal citation (as indicated in the metadata), and where appropriate, the data originator shall be involved.

Data and metadata generated within NAUTILOS, and which are stored at the originating institute/organization (which are the data owner-data provider and are responsible for the data, metadata and quality), are the same that are stored/made available with the NAUTILOS data portal (data assembly centre) and are the same that are made available to data integrator portals and initiatives (EMODnet, CMEMS, etc).

Whenever these integrators combine, integrate, elaborate, more generally process NAUTILOS data, it is recommended to acknowledge the data provenience (i.e. NAUTILOS) and the post-processing applied methods (for which NAUTILOS project is not responsible).

The NAUTILOS partners are not responsible for any use and misuse made by end-users.

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LIST OF ACRONYMS AND ABBREVIATIONS

Abbreviation	Definition
AdriFOS	Adriatic Fisheries and Oceanography Observing System
ACDD	Attribute Convention for Data Discovery
AES	Advanced Encryption Standard
AtlantOS	Optimizing and Enhancing the Integrated Atlantic Ocean Observing System
BEIS	Department for Business, Energy & Industrial Strategy, UK
BODC	British Oceanographic Data Centre
CC	Creative Commons
CDI	Common Data Index
CF convention	Climate and Forecast convention
CNR	Consiglio Nazionale delle Ricerche
CNR-IRBIM	Istituto per le Risorse Biologiche e le Biotecnologie Marine
CMEMS	Copernicus Marine Environment Monitoring System
CMEMS INSTAC	In Situ Thematic Centre
DAC	Data Archive Centre
DATAMEQ	EuroGOOS Data Management, Exchange, and Quality Working Group
DB	Database
DEFRA	Department for Environment, Food & Rural Affairs
DMP	Data management policy
Doi	Digital object identifier
DOOS	Deep ocean observing system
EDMO	European Directory of Marine Organisations

EC	European Commission
EEA	European Environment Agency
EMODnet	European Marine Observation and Data Network
ENISA	European Union Agency for Cybersecurity
EOV	Essential Ocean Variables
ERDAP	Environmental Research Division Data Access Program
EU	European Union
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
EuroGOOS	European component of the Global Ocean Observing System of the Intergovernmental Oceanographic Commission of UNESCO
FAIR	Findability, accessibility, interoperability, and reusability
FOS	Fishery Observing System
FGDC	Federal Geographic Data Committee
G7	Group of Seven
G20	Group of Twenty
GDAC	Global Data Assembly Center
GES	Good Environmental Status
GLODAP	Global Ocean Data Analysis Project
GOOS	Global Ocean Observing System
GRDP	General Data Protection Regulation
GTS	Global Telecommunication System
H2020	Horizon 2020 Framework Programme
HELCOM	Baltic Marine Environment Protection Commission
ICES	International Council for the Exploration of the Sea
INSPIRE	Infrastructure for Spatial Information in Europe
IOC/IODE	International Oceanographic Data and Information Exchange (IODE) of the Intergovernmental Oceanographic Commission
ISO	International Organization for Standardization
JERICO	Joint European Research Infrastructure of Coastal Observatories
JRC	Joint Research Centre
KPI	Key Performance Indicator
MAP	Mediterranean Action Plan
MEDIN	Marine Environmental Data and Information Network
MSFD	Marine Strategy Framework Directive
MEDITS	An international bottom trawl survey in the Mediterranean
NAUTILOS	New Approach to Underwater Technologies for Innovative, Low-cost Ocean observation
NetCDF	Network Common Data Form
OGC	Open Geospatial Consortium
ODV4	Ocean Data View 4
NERC	Natural Environment Research Council

NODC	National Oceanographic Data Committee
NUG	NetCDF Users Guide
NVS	NERC Vocabulary Server
NGOs	Non-governmental organization
OPeNDAP	Open-source Project for a Network Data Access Protocol
ORDP	Open Research Data Pilot document
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
PANGAEA	Data Publisher for Earth & Environmental Science
QC	Quality control
SEANOE	Sea scientific open data edition
SDN	SeaDataNet
SeaVoX	Vocabulary Content Governance Group
SOCAT	Surface Ocean CO2 ATlas
SOOS	Southern Ocean Observing System
SSL	Secure Sockets Layer
TAC	Thematic Assembly Centre
TSG ML	Technical Subgroup on Marine Litter
UN	United Nations
UNEP	UN Environment Programme
WCS	Web Coverage Service
WFS	Web Feature Service
WMTS	Web Map Tile Service
WMO	World Maritime Organisation
WMS	World Map Service
WoRMS	World Register of Marine Species
WP	Work Package
WAF	Web Accessible Folder

I. INTRODUCTION

Open ocean and deep-sea environments are a repository of valuable new knowledge on unexplored scientific phenomena, natural hazards and energy and sources opportunities. Due to the gap of long-term observation and technologically advanced systems, the research and exploitation of these environments is still at an immature and undeveloped stage.

NAUTILOS - New Approach to Underwater Technologies for Innovative, Low-cost Ocean observation is an H2020 project funded under the Future of Seas and Oceans Flagship Initiative, coordinated by the National Research Council of Italy (CNR, Consiglio Nazionale delle Ricerche).

It brings together a group of 21 entities from 11 European countries with multidisciplinary expertise ranging from ocean instrumentation development and integration, ocean sensing and sampling instrumentation, data processing, modelling and control, operational oceanography and biology and ecosystems and biogeochemistry such, water and climate change science, technological marine applications and research infrastructures.

NAUTILOS is one of two projects included in the EU's efforts to support of the European Strategy for Plastics in a Circular Economy by supporting the demonstration of new and innovative technologies to measure the Essential Ocean Variables (EOV).

The goal of NAUTILOS is to fill in existing marine observation and modelling gaps through the development of a new generation of cost-effective sensors and samplers for physical (salinity, temperature), chemical (inorganic carbon, nutrients, oxygen), and biological (phytoplankton, zooplankton, marine macrofauna) essential ocean variables, in addition to micro- and nano-plastics, to improve our understanding of environmental change and anthropogenic impacts. Newly developed marine technologies will be integrated in different observing platforms and deployed by using novel approaches from shore to deep-sea deployments.

The fundamental aim of the project is to complement and expand current European observation tools and services, to obtain a collection of data at a much higher spatial and temporal resolution and coverage than currently available at the European scale, and to further enable and democratise the monitoring of the marine environment to both traditional and non-traditional data users.

This document presents the NAUTILOS project Data Management Plan updated to month 18.

II. NAUTILOS PROJECT

NAUTILOS aims at developing and testing new technological solutions that will lower the costs of acquiring, deploying, maintaining, monitoring and observing stations to fill the *in situ* observational gaps of current ocean observation systems. This project will hence develop, integrate, validate and demonstrate new cutting-edge technologies with regards to sensors, interoperability and embedding skills. The development will always be guided by the **objectives of scalability, modularity, cost-effectiveness and open-source availability of data and software** products.

NAUTILOS is expected to collect, validate and process a huge amount of heterogeneous data that needs dedicated tools and services to favour integration and interoperability. Whenever possible, the developed data management infrastructure, tools and services will allow a data flow towards existing infrastructures and integrators globally accepted and used by the ocean observing community. Datasets acquired during the project through sensors and in-situ observation systems will be **made readily and freely available to these infrastructures and to the wider international ocean science community and other stakeholders.**

An on-line web user interface will provide the features to discover, access, retrieve sensors and platforms data, and will also represent the entry point for all the users (including citizen scientists) with an interest in validated environmental data collections. The interface will be designed considering specific dual requirements: an internal data storage and management area, and an externally visible and accessible area. Besides the classical marine data types, the project proposes to **acquire and manage new data** (e.g., digital images, micro-plastic observations etc.) whose harmonised data flow has yet to be designed and adopted at international level. The development is following models and schemes from the already existing infrastructures and propose itself as the champion/model for the establishment of these new data flows. This way, one key outcome of the project is to help adding and sharing more and better data and parameters. Behind the web interface, a standardisation and embedding process will make the data ready to dissemination and transfer to appropriate Data Archive Centres (DACs) and data management infrastructures (e.g., EMODnet) in their respective accepted formats.

Data management is based on recommendations from key target groups and stakeholder initiatives to facilitate a fast adoption and availability of the produced data.

As covered by deliverable D2.1 NAUTILOS is focusing on 17 instrumentation/tools (see Table 1 D2.1).

In this framework, NAUTILOS data management policy (DMP) includes and clarifies the data life cycle, the roles on the ownership and custodianship of the data, as well as the recommendations for data flow and citation.

Following the structure of the Horizon 2020 DMP template², In this framework, the NAUTILOS DMP will evolve during the lifespan of the project and next versions will present more details.

² C. Ramjoue and O. Marganne, “TEMPLATE HORIZON 2020 DATA MANAGEMENT PLAN (DMP),” 13 October 2016. http://ec.europa.eu/research/participants/data/ref/h2020/gm/reporting/h2020-tpl-oa-data-mgt-plan_en.docx.

III. DATA SUMMARY

Following the structure of the Horizon 2020 DMP template², in the following sections we present the NAUTILOS approaches to the key DMP indications.

1. WHAT IS THE PURPOSE OF THE DATA COLLECTION/GENERATION AND ITS RELATION TO THE OBJECTIVES OF THE PROJECT?

The purpose of NAUTILOS is to close the marine observation and modelling gaps for chemical, biological and deep ocean physics variables by means of next-generation cost-effective sensors and samplers, their deployment for large-scale demonstration in European seas and integration into observing platforms. This project therefore aims at complementing and expanding current European observation tools and services, to obtain a collection of data at a much higher spatio-temporal resolution and coverage, than currently available, and making the monitoring of the marine environment further available to both traditional and non-traditional data users.

In particular, the specific objectives of data collection are:

- to improve our understanding of environmental change and anthropogenic impacts related to aquaculture, fisheries, and plastic litter in coastal and shelf environments by means of improving current observing systems;
- to improve our understanding of open ocean and deep-sea environments;
- to improve the detection of plastic pollution to understand the input, distribution, and fate of plastics in European seas;
- to improve observing systems integrated to commercial activities such as fisheries, aquaculture, and ships of opportunity;
- to improve observing systems that utilise animal-borne instrumentation.

2. WHAT TYPES AND FORMATS OF DATA WILL THE PROJECT GENERATE/COLLECT?

The project deploys a set of sensors and samplers to measure a series of environmental variables and descriptors essential to understand the state of the ocean, its dynamics and properties, to quantify the forcing of the atmosphere-ocean boundary and to understand the role the oceans play in Earth's climate.

These variables consists of 14 physical, biogeochemical, biological and ecosystem essential ocean variables (EOVs), i.e. inorganic carbon, stable carbon isotopes, dissolved oxygen, inorganic macro nutrients, suspended particulate, ocean colour, ocean sound, phytoplankton biomass and diversity, zooplankton biomass and diversity, turtles, marine birds, marine mammals abundance and distribution, live coral, sea grass cover, microbial biomass and diversity and invertebrate abundance and distribution, two deep ocean observing system

(DOOS) specific EOVs, i.e. litter including micro-plastics, seafloor sponge habitat cover and nine EU MSFD descriptors.

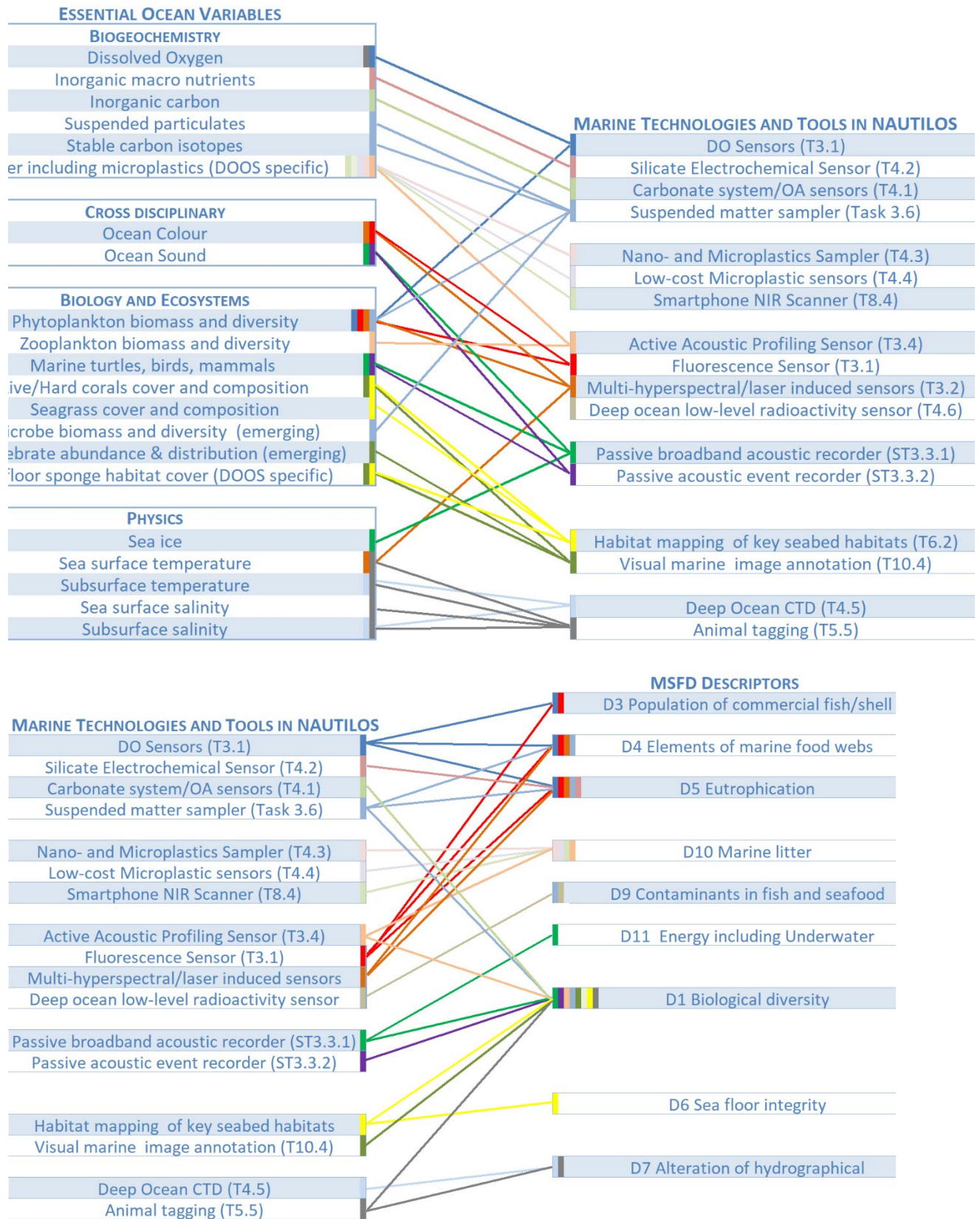


Figure 1 Environmental variables covered by NAUTILOS in terms of: Essential Ocean Variables (top); and MSFD descriptors (bottom) covered; updated following analysis performed in deliverable D2.1 (Figure 7).

There are two categories of data to be used within NAUTILOS:

- **internal project data**, i.e., data outputs from the project itself;
- **externally valuable environmental data**, i.e., real-world application data.

The data consists of a combination of numeric data (i.e., parameters measured by sensors), images and sounds from in situ fixed and moving platforms (time series, profiles, trajectories), and from model outputs (gridded data) that use collected data.

Those different types of data require different management methodology, storage capacities and standards.

While the data flow for classical ocean physical parameters such as temperature and salinity is well-defined³, some of the NAUTILOS variables, such as digital images, microplastic observations, and acoustic data, are part of new data flows and while the endpoint may be already defined, the in-between data standards are still under discussion.

One example to present the general case is “Marine litter”.

Marine Litter has been added to the EMODnet Chemistry scope since 2017. It is an important subject on the international political agendas such as of G7 and G20. It is very relevant for the MSFD agenda and is managed under the descriptor D10. This aims to provide instruments to assess, monitor, set targets and finally reach a good environmental status (GES) with regard to marine litter. GES should be achieved only when “properties and quantities of marine litter do not cause harm to the coastal and marine environment”.

To this end EMODnet Chemistry has developed products for these three main categories:

- Beach litter (i.e. nets, bottles etc.)
- Seafloor Litter (i.e. litter collected by fish trawl surveys)
- Micro-litter (i.e. micro plastics)

Starting from the outcomes of the already ongoing initiatives (Technical Support Group – Marine Litter (TSG ML), JRC Project on Marine Litter baselines, Regional Sea Conventions (OSPAR, HELCOM, UNEP/MAP, BSCS), ICES, MEDITS, etc.), EMODnet Chemistry implemented two main databases - one for the beach litter, modelled after the OSPAR-MCS approach, and one for the seafloor litter, modelled after the ICES-DATRAS approach – they collect a description of the detected elements, i.e. standardized description of the sampled element by using common terms from a standardized vocabulary.

³ <https://eurogoos.eu/data-management-exchange-quality-working-group-data-meq/>

In other terms, whatever is the methodology to collect the sample (e.g. manual annotation, taking a picture, taking a sample and processing it in the lab, etc.) the outcome of the procedure is a collection of information describing the litter.

		CATEGORIES FOR MICROPARTICLES	
		Material	Description
Size	Record size of each item. Minimum resolution is to allocate in to bin sizes of 100 μm	Plastic	Plastic fragments rounded
			Plastic fragments subrounded
			Plastic fragments subangular
			Plastic fragments angular
Type	Plastic fragments, pellets, filaments, plastic films, foamed plastic, granules, and styrofoam		cylindrical pellets
			disks pellets
			flat pellets
Shape	For pellets: cylindrical, disks, flat, ovoid, spheruloids; For fragments: rounded, subrounded, subangular, angular; For general- irregular, elongated, degraded, rough, and broken edges		ovoid pellets
			spheruloids pellets
			filaments
			plastic films
Colour	Transparent, crystalline, white, clear-white-cream, red, orange, blue, opaque, black, grey, brown, green, pink, tan, yellow		foamed plastic
			granules
			styrofoam
		Other	Other (glass, metal, tar)

Figure 2 Categories to describe microplastics appearance (extracted from *Guidance on Monitoring of Marine Litter in European Seas, MSFD Technical Subgroup on Marine Litter, 2013*).

This information is collected in a standard metadata format, i.e. Common Data Index (CDI)⁴ and ingested in the EMODnet Chemistry DB.

The scope of NAUTILOS DMP is to identify and describe these endpoints, to support NAUTILOS partners to collect and describe the relevant information that may be provided (or made available) to integrating infrastructure.

The final goal of NAUTILOS is to organize its data and make it accessible for relevant stakeholder by applying FAIR principles and exploiting machine-to-machine interoperability.

For the well-established parameters, NAUTILOS data management will adopt and implement standards from existing infrastructures (DACs and Global DACs) and integrators (e.g., EMODnet, CMEMS, JERICO⁵, ICES⁶, OGC⁷, DarwinCore⁸, etc) and once data is ready in the

⁴ <https://www.emodnet-chemistry.eu/repository/Proposal-EMODnet-TG-ML-Micro-Litter-Data-Gathering-03062020.pdf>

⁵ <https://www.jerico-ri.eu/>

⁶ <https://www.ices.dk/Pages/default.aspx>

⁷ <https://www.ogc.org/>

⁸ <https://dwc.tdwg.org/>

NAUTILOS back-end data infrastructure, stakeholder will be notified to start their up-taking process.

An example for ocean and meteorological parameters as collected by Fishing Vessels as opportunity observing system (FOS). Since 2021, the Ancona section of CNR-IRBIM is running the AdriFOS initiative: fishing vessels equipped with an integrated system for the collection of information on catches, position of the fishing operation, depth and water temperature during the haul, are producing a great amount of data for oceanographic (and biodiversity) purpose. The NAUTILOS DMP design how this data must be organized in the NAUTILOS backend system and define the procedure to inform NAUTILOS stakeholder that these data are available, more specifically, the NAUTILOS Data Manager is recommended to inform NAUTILOS stakeholder or initiate stakeholder ingestion procedure to let this data be consumed. Considering that this data can be operationally shared to EMODnet Physics, CMEMS INSTAC, etc., considering the EMODnet Ingestion system⁹, the NAUTILOS Data Manager is recommended to activate this EMODnet Ingestion procedure and follow up towards the integration steps.

Concerning NAUTILOS project activities, a series of documents and reports are planned and, some already achieved, coping with data management and its strictly connected issues, as agreed in the Annex 1 to the Grant Agreement. The list of documents follows in Table 1.

Table 1. List of data management documents in NAUTILOS

Document	Description with respect to Data Management and Nature
D1.3 Data Management Plan	Public ORDP: Open Research Data Pilot document. Submitted at M6
D1.10 Data Management Plan – 1st periodic report update	This document. Update of DMP at M18. Public ORDP: Open Research Data Pilot document.
D1.11 Data Management Plan – 2nd periodic report update	Update of DMP at M36. Public ORDP: Open Research Data Pilot document.
Final Data Management Plan	Finalization of the DMP at the end of the project. Public ORDP: Open Research Data Pilot document.
D8.3 Data Management Workflow	Description of common methods for parameter-platform management. Public report submitted at the end of 1 st year.
D8.4 Design of Thematic Assembly Center for innovative parameters	Description of how to set up a dedicated NAUTILOS assembly centre for new parameters. Other: design of software platform submitted at the end of 1 st year.

⁹ <https://www.emodnet-ingestion.eu/operational-data>

Document	Description with respect to Data Management and Nature
D9.5 KPI definition for the NAUTILOS data management and dissemination infrastructure	Description of the methodology for assessing production of new valuable data. Public report due at the end of 2 nd year.
D9.6 KPI assessment 1	Document for tracking impact of NAUTILOS in terms of data management and dissemination. Public report due at the end of 3 rd year.
D9.7 KPI Assessment 2	Document for tracking impact of NAUTILOS in terms of data management and dissemination, final update. Public report due at the end of the project.

2.1. Common data formats

The primary data format for the NAUTILOS data distribution is going to be the OceanSites netCDF-4 classic model¹⁰. NetCDF (Network Common Data Form) is a set of software libraries and machine - independent data formats that is the international standard for common data and it is the one adopted by all key European and international ocean data management infrastructures (Global DAC, CMEMS, EMODnet, SeaDataNet, etc.). For the historical validated datasets (fixed stations – mooring, tide gauge), the metadata format is the CDI (common data index) and the transport formats are ODV4 and NetCDF (CF convention - Climate and Forecast Metadata Convention).

The recommended implementation of NetCDF is based on the community-supported CF Convention, which provides a definitive description of the data in each variable, and the spatial and temporal properties of the data. The used version is CF-1.6 and it shall be identified in the ‘Conventions’ attribute. Any relevant metadata should be included whether it is part of the standard or not.

To fulfil its objectives and facilitate fast integration into international ocean data management infrastructures (e.g., GDAC, EMODnet, etc), NAUTILOS also adds some requirements to the CF-1.6 standard:

- Where time is specified as a string, the ISO8601 standard "YYYY-MM-DDThh:mm:ssZ" is used; this applies to attributes and to the base date in the ‘units’ attribute for time. UTC must be used and specified;
- Global attributes from Unidata’s NetCDF Attribute Convention for Data Discovery (ACDD) are implemented;
- INSPIRE directive compliance is recommended;
- Variable names (short names) from SeaDataNet P02 controlled vocabulary¹¹ are recommended;
- Platform types from SDN L06;

¹⁰http://www.oceansites.org/docs/oceansites_data_format_reference_manual.pdf

¹¹https://vocab.seadatanet.org/v_bodc_vocab_v2/vocab_relations.asp?lib=P02

- Institution codes: EDMO (European Directory of Marine Organisations)¹².

2.2. Global attributes

The global attribute section of a NetCDF file describes the contents of the file overall, and allows for data discovery. All fields should be human-readable and use units that are easy to understand. Global attribute names are case sensitive.

The European common data and metadata model for real-time data divides global attributes to be adopted for data in three categories: Mandatory Attributes, Recommended Attributes and Suggested Attributes.

The Mandatory Attributes (M) include attributes necessary to comply with CF-1.6 and OceanSITES conventions. The Recommended Attributes (R) include attributes necessary to comply with INSPIRE and Unidata Dataset Discovery conventions.

The Suggested Attributes (i.e., the others) include attributes that can be relevant in describing the data, whether it is part of the standard or not. All these attributes should be used and contain meaningful information, unless there are technical reasons making this impossible. Attributes are organized by function: Discovery and Identification, Geo-spatial-temporal, Conventions used, Publication information, and Provenance. Attributes that are part of the Attribute Convention for Data Discovery (ACDD) or Climate and Forecast (CF) standard, or that appear in the NetCDF Users Guide (NUG) are so indicated, as are those that are used by GDAC inventory software.

2.3. NAUTILOS Recommendations for interoperability in a nut

NAUTILOS has adopted a data interoperability infrastructure that is based on ERDDAP, GeoNetwork and GeoServer (to manage vectorial data and map layers). NAUTILOS provides the following main recommendations:

- (in situ/ex situ data) File format: NetCDF v.4.0
- Data model: OceanSITES/EuroGOOS DATAMEQ data model
- Metadata:
 - Time: ISO8601 standard "YYYY-MM-DDThh:mm:ssZ" is used; this applies to attributes and to the base date in the 'units' attribute for time. UTC must be used, and specified.
 - Latitude and longitude: WGS84
 - Implement Global attributes from - Attribute Convention for Data Discovery (ACDD)
 - Use GEMET-INSPIRE theme
 - Parameters: CF standard names, CF short names and SeaDataNet (SDN) P02/P09

¹² <https://edmo.seadatanet.org/>

- Institution codes: EDMO (European Directory of Marine Organisations)
- Country code: ISO 3166
- Data publishing service: ERDDAP + GeoServer
- Data catalogue service: GeoNetwork

3. WILL YOU RE-USE ANY EXISTING DATA AND HOW?

NAUTILOS will use relevant publicly available oceanographic dataset, such as those made available by key European data integration infrastructures.

For In Situ data the primary sources are:

CORIOLIS, CMEMS INSTAC, EMODnet, SeaDataNet.

For Remote Sensing data the sources are:

CMEMS, NASA (Aqua – MODIS), EUMETSAT (MetOP)

To note that, according EUMETSAT license agreement, data can be used by NAUTILOS partners for internal use (e.g. validation) but cannot be redistributed.

This data is going to be available to NAUTILOS partner by NAUTILOS data infrastructure – private area – under authentication and restriction systems (see also D8.3).

4. WHAT IS THE ORIGIN OF THE DATA?

To better understand the oceans, ocean observing technologies must be able to assess the spatial and temporal heterogeneity in the ocean with regards to physical processes, distribution of elements, ocean productivity, microbial to megafaunal biodiversity, and anthropogenic impacts related to fossil fuel emissions (i.e., ocean acidification), chemical pollutants, and litter/(micro)plastics. To achieve this, the ocean observing community must develop widely distributed observing systems equipped with low-cost and modular sensors and samplers on a variety of observing platforms.

NAUTILOS data is originated by the NAUTILOS sensors (oxygen, temperature, salinity, fluorescence, conductivity, light etc) that are mounted and carried by operating platforms (e.g., Ships of Opportunity, Fishing vessels, AUVs, tagged sea mammals etc).

Details on sensors specification are described in NAUTILOS WP3-WP4 Deliverables.

5. WHAT IS THE EXPECTED SIZE OF THE DATA? WHO MIGHT IT BE USEFUL TO ('DATA UTILITY')?

The expected size of the data is going to be in the range of terabytes.

The collected data will be made available to the wider community of ocean data users. NAUTILOS data are useful to **policy and decision makers**, including the European Commission, Parliaments, Member States officials, UN bodies, HELCOM and OSPAR commissions, EEA, supporting agencies of member state legislators, state agencies, governmental bodies, national funding agencies (i.e., DEFRA, BEIS in the UK). Many observation and monitoring programmes inform policies designed to enable the protection of the global oceans. The observation and monitoring technologies developed within the project can significantly contribute to policy aimed at promoting the good environmental status, conservation and protection of marine ecosystems. Key policy makers can benefit from a close collaboration with the project, they will be informed about the project's results, and will be actively engaged in providing feedback on whether project outcomes address current limitations, match the needs of those making decisions on policies affecting marine environment and answer future needs.

Other users are **commercial and industrial activities**, such as the fishing industry, aquaculture operators, offshore energy industry (oil and gas exploration, wind and tidal generation), seabed extractive activities, the tourism and recreation sector, marine biotechnology and bioprospecting, telecommunications, coastal protection, defence, search and rescue. Blue economy is a major contributor to the European economy, and the socio-economic benefits provided by the ocean are reliant on observations, measurements, and forecasts.

The **ocean research community** is definitely the target of this project, as will greatly benefit from the data generated for carrying out a variety of **projects in the areas of marine and earth observation**.

NAUTILOS is also directed to ocean-focused **NGOs and citizen scientists**, as they can share the knowledge, raise awareness, participate in project campaigns, and field work.

Finally, the data generated by NAUTILOS have the potential of supporting the generation of several downstream services and applications targeting the general public.

IV. FAIR DATA

NAUTILOS' general data management policy that is presented in the following sections has been developed in accordance with Horizon 2020 FAIR principles¹³, open data requirements and implementation guidelines.

It applies mainly to new results that will be produced in NAUTILOS that are to be made available by the project consortium as open source, open science and open data.

1. MAKING DATA FINDABLE, INCLUDING PROVISIONS FOR METADATA

- i. *Are the data produced and/or used in the project discoverable with metadata, identifiable and locatable by means of a standard identification mechanism (e.g., persistent and unique identifiers such as Digital Object Identifiers)?*

The data produced and used in the project will be discoverable with metadata and identifiable by means of a standard identification mechanism.

The collection and management of marine data metadata is a complex stepwise process that includes identification of the sensors, their configuration, the deployment at sea and collection of the observation that are regularly transmitted to a shore-located receiving station. The receiving station reformats the data messages, applying some automated quality control, and then distributes the data over one of the several communication pathways, like the Global Telecommunication System (GTS). Data Assembly Centres collect these data and develop added value reanalysis/products. Each step produces information that may be associated to the given observation, hence generating an immense volume of metadata information.

Data management associated with the ocean observing systems is, hence, scattered and requires a massive coordination effort. In this fragmented landscape, interoperability is essential to enable data to be used, reused, stored, and integrated. The building block for an integrated system in which components can exchange and understand information is the standardisation of formats, distribution protocols and metadata.

In this framework, NAUTILOS acts as the integrator by connecting different data sources (i.e. the NAUTILOS partners sensors and platforms).

It applies a minimum number of metadata elements designed to provide users with information identifying a collection of files as a thematic/coherent dataset.

It supports the search through those collections using keywords and spatial-temporal coordinates and will provide information on or links to the processing history of the observations (i.e., source, version, quality assessment and control, sensors).

¹³ https://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/hi/oa_pilot/h2020-hi-oa-data-mgt_en.pdf

The adoption of ISO standards and the use of shared controlled vocabularies are a key prerequisite towards consistency and this data integrator and data mediator role. ISO 19115 Standard¹⁴ requires a basic minimum number of metadata elements that are essential for the data presentation:

- Dataset or dataset series on specific challenges ('what'),
- Geographic bounding box ('where'),
- Temporal extent ('when'),
- Contact point to learn more about or order the dataset ('who').

The key references for cataloguing the information used in NAUTILOS are:

- ISO 8601 Representation of date and time,
- SeaDataNet NVS P0x description of parameters,
- Climate and Forecasting conventions for parameters standard names,
- WGS84 for Datum.

Some examples are Climate and Forecasting conventions for parameters that are mapped versus the NVS P01-P02, and the adoption of CMEMS INSTAC convention and recommendations for unique platform identification. Each platform in the CMEMS INSTAC has a unique code that, when available, is the WMO (World Maritime Organisation) code.

Following GOOS recommendation on tools to make data FAIR, to facilitate the data harmonisation and to operate as an integrator and data translator for facilitating data use and interoperability, NAUTILOS adopted ERDDAP¹⁵ as the core solution for data management (see D8.3 for detailed description on data management back-end infrastructure).

The goal is to make easier for users to access scientific data and ERDDAP supports both human interaction (e.g., OPeNDAP requests) and machine-to-machine interoperability. Moreover, ERDDAP data server supports several common data file formats (html table, netcdf, csv, txt, mat, json, etc.) and output files are created on the fly in any of these formats.

ERDDAP implements FGDC Web Accessible Folder (WAF) with FGDC-STD-001-1998 and ISO 19115 WAF with ISO 19115-2/19139. The second core data interoperability technology in NAUTILOS is GeoServer that implements several Open Geospatial Consortium protocols including Web Map Service (WMS), Web Feature Service (WFS), Web Coverage Service (WCS) and Web Map Tile Service (WMTS) and that was lately updated with the INSPIRE module. To extend further the users and uses of its products, NAUTILOS also implements web APIs and widgets.

¹⁴ <https://www.iso.org/standard/53798.html>

¹⁵ <https://www.ncei.noaa.gov/erddap/index.html>

ii. *What naming conventions do you follow?*

Whenever it is not possible to apply and harmonized approved naming convention (e.g., from EuroGOOS DATAMEQ), NAUTILOS will follow a NAUTILOS naming convention where the file name already provides the user with information of contents.

The following tags could be a possible template:

SOURCE.PROVIDER_

DISSEMINATION.CHANNEL_

PROCESSING.LEVEL_

PARAMETER_

PLATFORM_

PLATFORMTYPE_

DATATYPE_

TIMEFREQUENCY.TIMERESOLUTION_

e.g., NAUTILOS_ERD_L2_TEMP_GLIDERXXX_GL_PR_30m_1day

meaning that the source is NAUTILOS project, it is distributed by the NAUTILOS ERRDAP, it is a L2 processing level (as defined for remote sensing), it is a Temperature Profile dataset recorded by GliderXXX that is a glider, with a sample every 30m for 1 day.

iii. *Will search keywords be provided that optimize possibilities for re-use?*

Yes, search keywords will be provided based on the metadata and naming conventions.

iv. *Do you provide clear version numbers?*

All NAUTILOS products will be clearly labelled.

v. *What metadata will be created? In case metadata standards do not exist in your discipline, please outline what type of metadata will be created and how.*

NAUTILOS follows the recommendations set up by the EuroGOOS DATAMEQ, developed under CMEMS, EMODnet Physics and SeaDataNet/SeaDataCloud and further extended at international level under the AtlantOS project¹⁶.

Metadata used by the networks for parameters should be “mappable” on standard vocabularies existing and EU (SeaDataNet vocabularies) or international (CF or WoRMS for Taxa). More specifically, metadata are based on P01-P09 (parameter), P07 (CF variable), P06

¹⁶ <https://www.atlantos-h2020.eu/>

(units) L06 (platform types) from SeaDataNet controlled vocabularies managed by NERC/BODC (Vocabulary Server (version 2.0)).

Moreover, within the AtlantOS project An AtlantOS Essential Variables list of terms (aggregated level), related to ECV –EOV or other, has been defined and was published in June 2016 on the NERC/BODC Vocabulary Server (version 2.0) as A05 vocabulary (https://www.bodc.ac.uk/data/codes_and_formats/vocabulary_search/A05/).

Institutions listed in a data file shall be identified by a unique code from the EDMO existing catalogue. Quality control (QC) information will be attached to the data; both quality flags that can be mapped to SeaDataNet flag scale (available in the SeaDataNet Common Vocabularies (http://seadatanet.maris2.nl/v_bodc_vocab/welcome.aspx/) as list L201), and, whenever known, processing level information (“qualified in RT using automated procedures” or “processed in delayed DM by Scientist”).

Below is an example of an extract of the mapping defined for CMEMS INS TAC/EMODnet Physics between parameters in the data format and (P01 parameters + P06 units) in BODC controlled vocabularies.

Table 2. Example of metadata mapping

param	long_name	cf_standard_name	unit	sdn_parameter_u r	sdn_parameter_u r	sdn_uom_u rn	sdn_uom_uri
PRES	Sea water pressure, equals 0 at sea-level	sea_water_pressure	decibar	SDN:P01::PRESR01	http://vocab.nerc.ac.uk/collection/P01/current/PRESR01/	SDN:P061::UPDB	http://vocab.nerc.ac.uk/collection/P06/current/UPDB/
TEMP	Sea temperature in-situ ITS-90 scale	sea_water_temperature	degree_Celsius	SDN:P01::TEMPST01	http://vocab.nerc.ac.uk/collection/P01/current/TEMPST01/	SDN:P061::UPAA	http://vocab.nerc.ac.uk/collection/P06/current/UPAA/

2. MAKING DATA OPENLY ACCESSIBLE

- i. *Which data produced and/or used in the project will be made openly available as the default? If certain datasets cannot be shared (or need to be shared under restrictions), explain why, clearly separating legal and contractual reasons from voluntary restrictions.*

Part of the data and data products will have restricted access during a preliminary phase of the project. During this phase, these data and data products will be freely accessible to the consortium partners only. This private phase is necessary to make sure data are released for public access only after the required processing and quality control have been performed, as well as allowing partners some time to report results in scientific journals. NAUTILOS will implement a data management infrastructure composed of two mirror systems in which the first one will allow access only to project partners and the second one that is totally open to any user. As soon as the internal validation and assessment procedures are closed, the data/products will be moved from the first system to the second.

- ii. *Note that in multi-beneficiary projects it is also possible for specific beneficiaries to keep their data closed if relevant provisions are made in the consortium agreement and are in line with the reasons for opting out.*

This will be reported periodically.

- iii. *How will the data be made accessible (e.g., by deposition in a repository)?*

Data and products will be integrated into the NAUTILOS data infrastructure and NAUTILOS ERDDAP to facilitate the access, reuse, and further improvements of these results/products. As described in previous sections, the NAUTILOS infrastructure will implement the most recent dissemination catalogues and technologies and will link and deliver data into the most relevant ocean data management infrastructures and programs.

- iv. *What methods or software tools are needed to access the data?*

Data will be open and freely available and can be viewed and used by using well-known software tools.

- v. *Is documentation about the software needed to access the data included?*

Although the preference will always be open-source software, links to any needed software and documentation will be provided.

vi. *Is it possible to include the relevant software (e.g., in open source code)?*

All the needed software for accessing the data and products will be provided through the NAUTILOS portal, and open-source code will be available through typical defined Open Access repositories.

vii. *Where will the data and associated metadata, documentation and code be deposited? Preference should be given to certified repositories which support open access where possible.*

As described in the previous sections, data, metadata and documentation will be disclosed and deposited to key European ocean data infrastructures and repositories such as EMODnet, CMEMS, SDN and the NODC network, SEANOE. Other open repositories and initiatives such as ICES, PANGAEA, SOOS, SOCAT, etc. will also be used. Moreover, other general purpose but well-established repositories (e.g., Zenodo) are considered.

viii. *Have you explored appropriate arrangements with the identified repository?*

Project partners are involved in or are working with systems and infrastructures (see point above) and some arrangements are already in place.

ix. *If there are restrictions on use, how will access be provided?*

Before the full disclosure of the data, only project partners can access data and product. Access will be managed by an ad hoc authentication system.

x. *Is there a need for a data access committee?*

We do not see a need for a data access committee because all regulations are unambiguous.

xi. *Are there well described conditions for access (i.e., a machine-readable license)?*

Machine-to-machine is based on the most recent technologies, the premise is a CC BY-SA or CC BY-NC license.

xii. *How will the identity of the person accessing the data be ascertained?*

Once data will be published, they will be public and accessible without any restriction nor authentication needed. NAUTILOS will monitor the typology of user (in compliance with GDPR) by means of a web form that would be filled on voluntary base. Specific templates for various usages of informed consent and all the procedures defined within NAUTILOS have been provided and specified within the deliverables D13.1 and D13.2, pertinent to the Ethics Work Package 13. Updated informed consent forms, analysed within the NAUTILOS Ethical Advisory Board, are under development and will be submitted as part of the deliverable D13.7 at the same time as this present document. In the deliverable various versions of the forms

will be prepared in different languages which will be used by different NAUTILOS partners in different countries.

3. MAKING DATA INTEROPERABLE

- i. *Are the data produced in the project interoperable, that is allowing data exchange and re-use between researchers, institutions, organisations, countries, etc. (i.e., adhering to standards for formats, as much as possible compliant with available (open) software applications, and in particular facilitating re-combinations with different datasets from different origins)?*

Yes. See previous sections.

- ii. *What data and metadata vocabularies, standards or methodologies will you follow to make your data interoperable?*

An updated list of the vocabularies adopted in NAUTILOS is presented in Table 3

Table 3. Metadata Vocabularies

Metadata field	Vocabulary exists	Link to vocabulary	Vocabulary governance
Platform type	Yes	http://vocab.nerc.ac.uk/collection/L06/current/	BODC
Platform type bigram	Yes	CMEMS INSTAC	EuroGOOS DATAMEQ
sensor_model	Yes	http://vocab.nerc.ac.uk/collection/L22/current/	BODC -NVS
ICES_code	Yes	https://ocean.ices.dk/codes/ShipCodes.aspx	ICES
contributors_role			NAUTILOS
naming_authority	Yes	https://edmo.seadatanet.org/	SeaDataNet
Institution	Yes	https://edmo.seadatanet.org/	SeaDataNet
rtqc_method	*	doi	
data_mode	Yes	RT/DM/REP	EuroGOOS DATAMEQ
Phase	No		NAUTILOS
variable names	Yes	http://vocab.nerc.ac.uk/collection/P02/current/ http://vocab.nerc.ac.uk/collection/P01/current/ http://vocab.nerc.ac.uk/collection/P07/current/	BODC - NVS
Time	yes	ISO8601	ISO
Datum	Yes	WGS84	ISO
Taxon	Yes	LSID	WoRMS
Country	yes	ISO3166	ISO
Licence	Yes	https://creativecommons.org/	CC
INSPIRE	Yes	ISO 19115	ISO/INSPIRE

*) RTQC are usually described in scientific papers, here the recommendation is to include the “doi” of such paper-methodology.

- iii. *Will you be using standard vocabularies for all data types present in your dataset, to allow inter-disciplinary interoperability?*

Yes. See previous sections.

- iv. *In case it is unavoidable that you use uncommon or generate project specific ontologies or vocabularies, will you provide mappings to more commonly used ontologies?*

Controlled vocabularies consist of lists of standardised terms that cover a broad spectrum of disciplines of relevance to the oceanographic and wider community. Using standardised sets of terms solves the problem of ambiguities associated with data mark-up and enables records to be interpreted by computers. This opens datasets to a whole world of possibilities for computer aided manipulation, distribution and long-term reuse. In this framework, an important outcome of a past ICES/IOC Study Group on the Development of Marine Data Exchange Systems was the establishment of a combined SeaDataNet and MarineXML Vocabulary Content Governance Group (SeaVoX), moderated and maintained by NERC-BODC (NERC Vocabulary Server – NVS). SeaVoX operates by a mailing list server, open to anyone with a genuine interest in controlled vocabularies for the marine science domain (it has an active membership of experts from SeaDataNet, IOC/IODE, ICES and other international groups).

The NVS offers both NVS RESTful, SOAP and SPARQL services. A GitHub repository for key NVS vocabularies¹⁷ tracks the discussion on new terms adoption. NAUTILOS partners are already using these services and are collaborating with SeaDataNet and linked projects (e.g., EMODnet).

The NVS service is also open to map and manage new terms and ontologies, therefore the primary approach of NAUTILOS will be to interact with the service (and the people managing the vocabulary) to have a community definition, acceptance and hence adoption of new proposed terms.

¹⁷ github.com/nvs-vocabs

4. INCREASE DATA RE-USE (THROUGH CLARIFYING LICENSES)

i. *How will the data be licensed to permit the widest re-use possible?*

CC BY-SA or CC BY-NC licenses. In some cases, to be identified, and depending on the data/document, CC BY or CC0 (public domain) can be taken into consideration.

ii. *When will the data be made available for re-use? If an embargo is sought to give time to publish or seek patents, specify why and how long this will apply, bearing in mind that research data should be made available as soon as possible.*

The general approach is presented in the previous sections. In general, data will be made available as soon as possible, with the latest being the end of the project.

iii. *Are the data produced and/or used in the project useable by third parties, in particular after the end of the project? If the re-use of some data is restricted, explain why.*

Data and products produced or used in the project are encouraged to be used and adopted by third parties as soon as possible. We are certain that all data produced in this project will be of importance to the wider scientific community and to future projects.

iv. *How long is it intended that the data remains re-usable? Are data quality assurance processes described?*

Data quality and data quality flag approaches are documented. Moreover, we intend to apply versioning of the data and products to facilitate the re-usability of the data for the longest period possible.

Data will be stored in data repositories and in principle will be available and re-usable indefinitely. Selected data repositories will provide the NAUTILOS data with a permanent digital object identifier (“doi”) - according to DataCite¹⁸ model. Having a data-doi enables data provenience traceability, citation and acknowledgment, as well as long term availability and reusability of data. DataCite repositories such SEANOE, PANGAEA, Zenodo (and many others) have the commitment to maintain the data repositories.

As described in the previous sections, NAUTILOS DMP describe the methods to organize the data during the project life (see also D8.3) and how to provide and link NAUTILOS data towards European and Global integrators where the entry point for this interoperability action (i.e. EMODnet Ingestion) is designed to offer data with doi whenever data has not it yet. According the NAUTILOS DMP, NAUTILOS data has to be accompanied by metadata and metadata reports on the applied data quality procedure. These metadata do not describe the procedures themselves, but they regulate and provide a field with a link to the applied

¹⁸ <https://datacite.org/value.html>

procedure (see also Table 3). These simple procedures are the key cornerstones for ensuring project' data reusability and data long term legacy and traceability.

v. *Further to the FAIR principles, DMPs should also address:*

In the European legislative context, NAUTILOS encourages data providers to comply with metadata encoding following the requirements of the INSPIRE directive as well as the Directive 2003/4/EC¹⁹. Therefore, INSPIRE compliant XML formats such as ISO 19115 or accordingly enriched simpler formats such as extended Dublin Core are the preferred metadata profile. If metadata is integrated within a data file, the file needs to be in an agreed format such as OceanSites NetCDF format.

¹⁹ DIRECTIVE 2003/4/EC „on public access to environmental information and repealing Council Directive 90/313/EEC“

V. ALLOCATION OF RESOURCES

i. *What are the costs for making data FAIR in your project?*

Besides the development and hosting of the data infrastructure that enables the compliance with FAIR principles, mainly allocated by the partner ETT, all the partners have allocated a dedicated budget for the promotion and dissemination activities.

ii. *How will these be covered? Note that costs related to open access to research data are eligible as part of the Horizon 2020 grant (if compliant with the Grant Agreement conditions).*

Wherever the project will be presented, the presentations will report links to the NAUTILOS data infrastructure and instructions and information on how NAUTILOS implements the data and products Findability, Accessibility, Interoperability and Reusability.

iii. *Who will be responsible for data management in your project?*

Data Management is included in a dedicated project work package (WP8) and responsible for the data management is Antonio Novellino, who has long experience in data management and ocean data management and sharing. Following is his employment history in brief.

He holds a PhD in Biotechnology and Bioengineering, MSc Biomedical Engineering, Research Manager at ETT, Coordinator of EMODnet Physics. He has been involved in R&D projects at both National and European level for the past 15 years. From 2008 to 2010, he served the European Commission, JRC – IHCP as a senior researcher. At present, he is the ETT Research Manager and he is coordinating the R&D department activities. He serves on the Board of Directors of Consortium Si4Life (manager of Polo Si4Life - Life Sciences Liguria Region - www.si4life.com), he served on the board of Consortium Tecnomar (about 100 companies working on maritime and environment technology, www.consorziotecnomar.com). He serves the techno-scientific board of the Ligurian Cluster of Marine Technology DLTM (www.dlrm.it) and the board of Consortium TRAIN (innovation in energy and transport management, www.consorziotrain.org) and is member of the EuroGOOS DATAMEQ group for advising (<http://eurogoos.eu/>) on operational oceanography data management procedures. He serves the EMODnet Steering Committee, the EMODnet Technical Working Group. He serves the Expert Team on WIS Centres (ET-WISC) and Task Team on Data Centres (TT-DC). He is co-author of scientific publications and he participates as reviewer for scientific journals for Elsevier and Frontiers. He proactively supported EGU ESSI 1.1/OS4.35 session since 2014. He is the EMODnet Physics coordinator and CMEMS DU/MDS deputy coordinator.

- iv. *Are the resources for long term preservation discussed (costs and potential value, who decides and how what data will be kept and for how long)?*

For the duration of the project, data is going to be hosted by the NAUTILOS data management infrastructure. This infrastructure is going to be interoperable with the key European integrating data ocean infrastructures and programs (CMEMS, EMODnet and SeaDataCloud) and new data will directly be harvested by these long-term safe keeping systems. It should be noted that EMODnet and in particular by means of the EMODnet Data Ingestion and Safe Keeping project, is implementing a dedicated action to collect and provide long-term preservation of ocean data and NAUTILOS DMP already consider this system for its data legacy (see also section 4.iv). Moreover, NAUTILOS designed a specific Task (Task 9.5) to further investigate and describe a procedure to deal with data legacy and integration into European platforms. As already stated, a specific goal of NAUTILOS project and DMP is to perform long term data stewardship and data legacy in collaboration with other key European networks such as the SeaDataNet network of National Oceanographic Data Centres and IODE centres.

VI. DATA SECURITY

- i. *What provisions are in place for data security (including data recovery as well as secure storage and transfer of sensitive data)?*

The NAUTILOS infrastructure is going to be deployed on the ARUBA.it infrastructure²⁰. Since 2015 Aruba is running a dedicated service to private business clients and it provides the client with top level services such as Data Centre (Virtual Servers, Real Servers, hosting infrastructures), Back up and Disaster Recovery etc. ARUBA also provides us with most recent services for data security cryptography (AES), security protocols (AES, SSL) and bandwidth balance. The main characteristics of the service are:

SLA	99,80%
security	crypted transmission channel (optional) storage crypting AES-256
min backup timing	1h
schedule	anytime granularity – single backup job
Backup Account number	unlimited
concurrent agents	depends on the agreed service
max number of backup jobs	unlimited
bandwidth	unlimited (upload/download)
Certifications	ISO 9001:2015, ISO 27001:2013
service desk	24h
Cloud security certification	ISO/IEC 27017:2015
data privacy	ISO/IEC 2018:2014
security incidents:	ISO/IEC 27035:2016

- ii. *Is the data safely stored in certified repositories for long-term preservation and curation?*

While the ARUBA infrastructure is going to guarantee the data security, back up and disaster recovery services, for long term preservation and curation, as described in the previous paragraph, the NAUTILOS project will work in collaboration with the major ocean data infrastructure, which has the mandate for long-term data curation and preservation: EMODnet and in particular the Data Ingestion and Safe Keeping project, ICES, SeaDataNet networks of NODCs, CMEMS. The NAUTILOS partners are also involved in other global initiatives (SOCAT, GLODAP, etc) and NAUTILOS data will be also shared (and clearly NAUTILOS labelled) and made available towards these infrastructures.

²⁰ <https://business.aruba.it/azienda.aspx>

VII. ETHICAL ASPECTS

- i. *Are there any ethical or legal issues that can have an impact on data sharing? These can also be discussed in the context of the ethics review. If relevant, include references to ethics deliverables and ethics chapter in the Description of the Action (DoA).*

All the ethical aspects of this project are covered under WP13 and its deliverables.

- ii. *Projects participating to the ORDP might present information relevant to the ethical aspects (data protection) in the DMP. In such a case, the ethics chapter of the DoA may simply refer to the DMP for more information on the details of the ethics aspects related to data.*

All the ethical aspects of this project are covered under WP13 and its deliverables.

- iii. *Is informed consent for data sharing and long-term preservation included in questionnaires dealing with personal data?*

Whenever the NAUTILOS project will implement surveys, questionnaires, or collect personal data for any reason (e.g., attendance to organized events), European GRDP law will be used as reference and the user will be informed about the use of personal data. In general, NAUTILOS will not transfer personal data (e.g., email addresses) to other entities and the only use will be setting up a distribution list to inform users about project progress. User will be always able to change his consensus and ask for being removed from the distribution channel. More details, as well as the templates prepared for the Ethics Work Package are available as the deliverable documents for WP13. In particular, D13.1 and D13.2 dealing with personal data and procedures and criteria that will be used to identify/recruit research participants, as well as the informed consent procedures that will be implemented for the participation of humans external to NAUTILOS to the project activities and in regard to their data processing. As previously mentioned, and following the establishment of the Ethical Advisory Board in NAUTILOS, an update of the informed consent forms is being prepared. It will be submitted with deliverable D13.7, which is expiring at the same time as this document. The updated forms will be available in different languages according to the needs of the various NAUTILOS partners, who will have to carry out activities related to personal data.

VIII. OTHER ISSUES

- i. *Do you make use of other national/funder/sectorial/departmental procedures for data management? If yes, which ones?*

Nothing to report.

- ii. *Further support in developing your DMP*

Nothing to report.

APPENDIX 1: REFERENCES AND RELATED DOCUMENTS

ID	Reference or Related Document	Source or Link/Location
1	GDPR	https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32016R0679
2	EU Regulation	https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32016R0679&from=EN#d1e3722-1-1
3	ISO 27001	https://en.wikipedia.org/wiki/ISO/IEC_27001
4	ENISA - Handbook on Security of Personal Data Processing - 2017	ISBN 978-92-9204-251-6, DOI 10.2824/569768
5	European Data Protection Board (2020).	https://edpb.europa.eu/sites/edpb/files/consultation/edpb_recommendations_202001_supplementarymeasurestransferstools_en.pdf
6	European University Institute (2019). Guide on Good Data Protection Practice in Research	https://www.eui.eu/documents/servicesadmin/deanofstudies/researchethics/guide-data-protection-research.pdf