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## Glossary

Acronym	Name	Meaning	Examples
DPS	Data Product Specification	Ideal tool to answer a challenge	Web-application for ship routing
TDP	Targeted Data Product	Actually realized state of a DPS	Web-application for ship routing
UD	Upstream data	Input data employed in the TDP	Environmental datasets (from observations and/or numerical geophysical model)
	Challenge	A targeted end-user application (the end-use case) upon which the checkpoint methodology is applied	ship routing hazard maps
	Characteristic	Ocean Variable of the UD used in the TDP	Ocean gravity waves, ocean currents
	Quality element	Property of a characteristic	spatial resolution, temporal resolution, temporal coverage, etc.
	Quality error	Distance between quality element in UD or TDP and corresponding quality element in DPS	
VISIR	discoVerIng Safe and efficient Routes	Ship routing model	
CMEMS		Copernicus Marine Environment Monitoring Service	
GEBCO		General Bathymetric Chart of the Oceans	

GSHHG	A Global Self-consistent, Hierarchical, High-resolution Geography Database
NOAA	National Oceanic and Atmospheric Administration

## 1. Executive Summary

The fitness for purpose of the AtlantOS targeted products for ship routing has been evaluated by means of an objective methodology. It makes use of concepts from the EMODnet checkpoints approach as well as ISO industry standards. The outcome is a partial but still quite high degree of fitness for purpose, mainly limited by spatial and temporal coverage of the products.

The methodology is also applied to evaluation of the fitness for use of the input datasets used in the AtlantOS ship routing products. To this end, both appropriateness and availability indicators are considered, and their scores are awarded by means of an expert judgment and use of the Sextant platform. The outcome is a totally adequate fitness for use of the input datasets for the AtlantOS ship routing products.

## 2. Introduction

Societal benefit products are situated at the end of a quite long value adding chain. Building useful science-based data products starts with ocean observations that, through data assembly and data assimilation into numerical geophysical models, flow into analyses and forecast fields. Then, these “generic data products”, through specific transformation models, generate “Targeted Data Products” or customized data products.

AtlantOS Task 8.3 transformed AtlantOS generic data products from the Copernicus Marine Environment Monitoring Service (CMEMS) into a customized data product that provides the end-users with low carbon ship route options across the Atlantic. It is available to view on a web application<sup>1</sup> that was documented in AtlantOS Deliverable 8.10 report. In particular, a new version of the VISIR<sup>2</sup> (discoVerIng Safe and efficient Routes) ship routing model was developed in AtlantOS and employed to compute time-optimal ship tracks in the Atlantic Ocean. This allows an assessment of carbon intensity reduction using an Energy Efficiency Operational Indicator (EEOI). The 2017

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<sup>1</sup> <https://www.atlantos-visir.com/>

<sup>2</sup> <http://www.visir-model.net/>

environmental conditions from CMEMS analysis fields of ocean currents and waves were used in this AtlantOS demonstrator.

The fitness for use of the input datasets and the fitness for purpose of the developed product are assessed and discussed in this report. The assessment presented here was motivated by a need to objectively identify if gaps exist in the ocean observing and information system that would reduce the quality and usefulness of the ship routing specific Targeted Data Product. Identifying ocean observing gaps can help funders and operators determine future priorities; e.g., where to deploy marine observing infrastructure, and where investment along the value chain is required to support the Blue Economy.

Since the consolidated EMODnet checkpoint methodology is proven to be an effective assessment tool, this approach was used also to assess the ship routing product.

In the following sections, we will explain the fundamentals of the assessment methodology and report its results, i.e. the usefulness of the upstream data to develop the downstream product and the usefulness of the developed downstream application “AtlantOS ship routing” for the end-users. The conclusions are presented at the end of the report.

### 3. Assessment Methodology

The concept of EMODnet Sea-Basin Checkpoints was introduced within the Green Paper “Marine Knowledge 2020: from seabed mapping to ocean forecasting” (COM-2012-437).

The EMODnet assessment of the adequacy of the basin-scale observing and monitoring system was first developed for the Mediterranean Sea (<http://www.emodnet-mediterranean.eu/>, Pinardi *et al.*, 2017) and the North Sea, and has since been extended to the Arctic, Atlantic, Baltic, and Black Sea (<http://www.emodnet.eu/checkpoints>). In Pinardi *et al.* (2017), seven challenges were considered: Windfarm siting, Marine Protected Areas, Oil Platform leak, Climate and Coastal Protection, Fisheries Management, Marine Environment, River inputs.

The EMODnet assessment methodology adopts industry standard vocabulary and rules (ISO19113, ISO 8402, ISO 19115, ISO 19157). It is an effective way to assess many targeted science-based data products or, in EMODnet language, “application Challenges”.

In AtlantOS WP8 several challenges were considered:

- Harmful Algal Blooms (Task 8.1)
- Storm surge (Task 8.2)
- Ship routing hazard maps (Task 8.3)
- Oil Spill (Task 8.4)
- Aquaculture (Task 8.5)
- Marine Strategy Framework Directive (Task 8.6)
- Atlantic Albacore distribution (Task 8.7)

Related data products are described at <https://www.atlantos-h2020.eu/products-for-end-users/>.

In AtlantOS Task 8.3 a system to compute safe and optimal Atlantic Ocean ship tracks was developed, starting from a Mediterranean Sea VISIR model version (Mannarini *et al.*, 2016). This

model version was further developed and advanced to cater for the Atlantic Ocean with new features documented in detail in a recently submitted manuscript (Mannarini & Carelli 2019, in review).

Results of the optimal ship track computation are displayed on a web interface (<https://www.atlantos-visir.com/>) that allows the user to browse the optimal Atlantic Ocean tracks and associated EEOI (Energy Efficiency Operational Indicator) savings.

The EMODnet checkpoint methodology refers to three fundamental objects, defined as follows:

- “Data Product Specification” (DPS): The DPS is a technical description of the science-based data product. The data product specification is created using information on what the end-user needs. In some case, a direct involvement of the end-user is possible (“open innovation” approach). In its actual implementation, such a “dream” product may or may not be fulfilled; this will depend on the availability of and quality of the data used to develop the product as well as on the actual contents the developers put into the Targeted Data Product (TDP, see below). The DPS defines how the dataset should be and provides the basis to allow the assessment of the Upstream Data (UD) sets supplied to- and used by- the Targeted Data Products (TDP).
- “Upstream Data” (UD): The input datasets used to create the final science based downstream product i.e. the Targeted Data Product (TDP), in this case the “AtlantOS ship routing” data product. Here we anticipate that the EMODnet assessment to determine the fitness for use looks at the difference between the required input data (dream dataset), as specified in the DPS, and the actually available dataset used to create the “AtlantOS ship routing” TDP.
- “Targeted Data Product” (TDP): The precise technical description of the actual product developed. This information is used to assess the fitness for purpose of the realised product.

The assessment methodology adopted some ISO quality elements and subdivided them into two territories; one called “availability” and the other “appropriateness”.

**Availability Scores** refer to how easily data are found, accessed, previewed, downloaded. They are determined by experts following an evaluation template.

**Appropriateness Scores** refer to properties (or “quality elements”) of the characteristics of a product and are evaluated as differences between expected and implemented quality values (“quality errors”).

The final adequacy score of the product is then assessed from the scores awarded in these two territories (Figure 1).

## WHAT ARE CHECKPOINT INDICATORS?

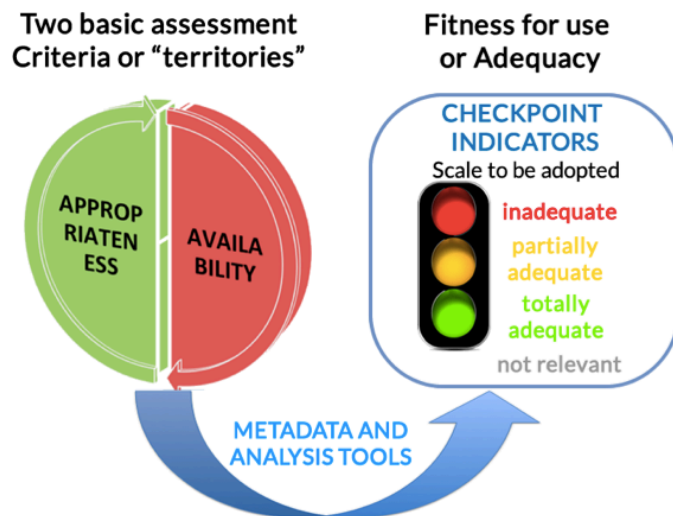


Figure 1 Relation between checkpoint territories and checkpoint indicator of adequacy.

### 2.1 Targeted Data Products

The targeted data product components produced by this task are two:

- 1) The bundle of optimal ship tracks in 2017
- 2) Related energy savings in terms of Energy Efficiency Operational Indicator (EEOI).

AtlantOS D8.10 report provides details why bunker costs were replaced by EEOI savings, and how the hazard maps are related to the constraints for intact vessel stability and stochastic correlation of the ocean currents fields. Further information is available at [www.atlantOS-visir.com](http://www.atlantOS-visir.com) (open and free policy) and an exemplary screenshot is provided in Figure 2.

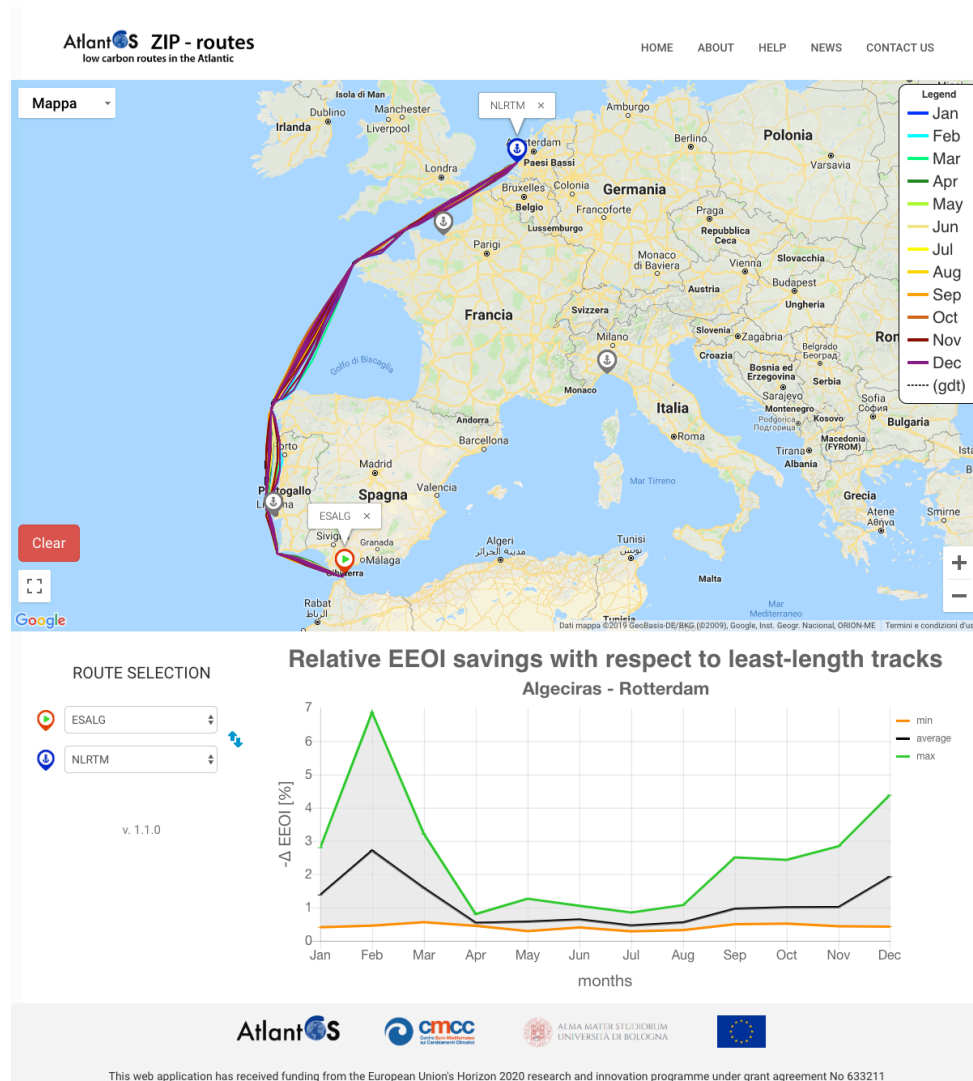


Figure 2 Screenshot of AtlantOS Task 8.3 targeted products for the Algeiras-Rotterdam route; displayed through the web application [www.atlantos-visir.com](http://www.atlantos-visir.com). Upper panel presents an example of product component #1 = the hazard maps, and the lower panel shows product component #2 = the EEOI savings timeseries.

### 3.2. Upstream Data (UD)

The Upstream Data considered for the two Targeted Data Products include:

1. Shoreline
2. Bathymetry
3. Eastward surface current velocity
4. Northward surface current velocity
5. Significant wave height
6. Wave direction
7. Wave peak period

1. The shoreline is used to generate the graph of available nodes and edges. The global shoreline dataset GSHHG was obtained from NOAA. There are five versions of the database, with a spatial resolution of about 200 meters, in the best case.



**2.** The General Bathymetric Chart of the Oceans (GEBCO) is used for Bathymetry. The dataset has a spatial resolution of 30 arcsec (i.e., 0.5 nmi<sup>3</sup> in the meridional direction) and with the most recent update completed in 2014. Bathymetry is necessary to define shallow areas that must be avoided for safety reasons by the vessels (ships).

**3 to 4.** Ocean currents were obtained from CMEMS operational Mercator global ocean analysis and forecast system. The spatial resolution is 1/12 degree, i.e., 5 nmi in the meridional direction. The time series starts on 27<sup>th</sup> December, 2006 and has a daily time step. The dataset name is GLOBAL\_ANALYSIS\_FORECAST\_PHY\_001\_024 on the CMEMS server. Current magnitude and direction have an impact on the time needed to move from one node to another node.

**5 to 7.** Wave analyses are obtained from CMEMS, the operational global ocean analysis and forecast system of Météo-France. The spatial resolution is 1/12 degree, i.e. 5 nmi in the meridional direction. The wave dataset name is called GLOBAL\_ANALYSIS\_FORECAST\_WAV\_001\_027 on the CMEMS server. Significant wave heights influence vessel speed according to the wave response function. Wave direction and wave peak are used to evaluate if a path respects safety constraints. In a (VISIR) pre-processing stage, we averaged three-hourly instantaneous fields of integrated wave parameters from the total spectrum (Spectral significant wave height, Mean wave direction, Wave period at spectral peak into daily fields.

### 3.3. Data Product Specification (DPS)

Table and Table describe the original end-user specification for the two ship routing data product components assessed in this report.

**Table 1 Description of first product component for AtlantOS Task 8.3, i.e., the bundle of optimal ship tracks**

Product component	AtlantOS_Task83_Product1
Product component description	Map of optimal tracks, considering ocean gravity waves and surface ocean currents, and accounting for safety constraints
Geographic description	whole Atlantic basin
Horizontal extent	-
Horizontal resolution	Mesh resolution: 10 nmi; Path resolution: 60 nmi.
Horizontal accuracy	-
Vertical extent	-
Vertical resolution	-
Vertical accuracy	-
Temporal extent	2015, 2016, 2017
Temporal resolution	It will be given by the time needed to sail between waypoints. Assuming a vessel speed of 15 kts, it could be in the order of 60 nmi/15 kts = 4 hours.
Temporal accuracy	-

<sup>3</sup> 1 nmi = 1852 m (definition of "nautical mile")

Spatial representation	Geodetic track and bundle of optimal tracks
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**Table 2 Description of second product component of the DPS for AtlantOS Task 8.3, i.e. related energy savings in terms of Energy Efficiency Operational Indicator (EEOI).**

Product component	AtlantOS_Task83_Product2
Product component description	Statistical distribution of energy-efficiency gains, considering gravity waves and surface ocean currents
Geographic description	whole Atlantic basin
Horizontal extent	-
Horizontal resolution	-
Horizontal accuracy	-
Vertical extent	-
Vertical resolution	-
Vertical accuracy	-
Temporal extent	2015, 2016, 2017
Temporal resolution	-
Temporal accuracy	-
Representation	Histograms of EEOI savings

## 4. Assessment results

Assessment results are organised into discussions on:

- fitness for use of the Upstream Data (Sect.4.1)
- fitness for purpose of the Targeted Data Product (Sect.4.2)

The assessment is complemented by addressing a few questions common to all AtlantOS WP8 end-use cases or application challenges.

### 4.1. Fitness for use of the Upstream Data (UD)

According to the Checkpoint methodology, for the UD, two basic assessment criteria or “territories” are considered; 1) availability and 2) appropriateness. These territories are addressed in the following two subsections.

#### 4.1.1. Availability indicators

Following the Mediterranean Sea Data Adequacy Report (Pinardi *et al.*, 2017), eight availability indicators are considered and evaluated for each characteristic<sup>4</sup>.

Availability indicators	Short definition / Full question	Value	Flag
AV-VI-1	Easily found Can the data sets or series of datasets be found easily ?	1. Cited in peer reviewed paper or grey literature but no info on how to access	LOW VISIBILITY (red color)
		2. Information retrieved upon specific request to the data source	
		3. Use of social network, community of practices sharing information, portals of organization where no search is organized by an engine	MEDIUM VISIBILITY (orange color)
		4. Use of open search engines, searching by name either the data provider or the characteristics	HIGH VISIBILITY (green color)
		5. Search via reference catalogue (e.g. MyOcean, GEOSS Geoportal, ...)	
Availability indicators	Short definition / Full question	Value	Flag
AV-VI-2	EU Catalogue service Is the dataset referenced by a EU catalogue service or other bodies (private or public), national or international non EU services	1. The data sets are not referenced in a catalogue or are referenced in a non public catalogue	LOW VISIBILITY (red color)
		2. The datasets are referenced in a public national catalogue, or in an international catalogue service	MEDIUM VISIBILITY (orange color)
		3. The datasets are provided through an EU Inspire catalogue service (OGC)	HIGH VISIBILITY (green color)
Availability indicators	Short definition / Full question	Value	Flag
AV-AC-1	Visibility of data policy How visible is the data policy adopted by data providers ?	1. There is no information at all on data policy adopted by data providers	LOW TRANSPARENCY (red color)
		2. There is information, but details are available only on request	MEDIUM TRANSPARENCY (orange color)
		3. There is detailed information provided to understand data policy	HIGH TRANSPARENCY (green color)
Availability indicators	Short definition / Full question	Value	Flag
AV-AC-2	Data Policy What is the data policy ?	1. Not or not well documented	LOW SHARING (red color)
		2. Restricted	
		3. Accessible under moratorium	MEDIUM SHARING (orange color)
		4. Unrestricted	HIGH SHARING (green color)

Figure 3. Checkpoint availability indicators, part a)

The number values assigned to each indicator varies. For example, availability indicator, AV-VI-1 has five enumerations, while AV-VI-2 has three enumerations (Figure 3), and AV-PE-1 has four enumerations (Figure 4).

To ensure score comparability across indicators, the scores are reported within a range from 1 to 3. The number assigned depends on the flag (or chromatic label) associated to the score, according to the rule:

<sup>4</sup> As we write, the Med. Sea checkpoint portal is offline. However, the availability indicators are also reported at this weblink <http://emodnet-blacksea.eu/the-availability-indicators>. Screenshots in Figure 3 and Figure 4 originate from this website.

red → 1, yellow → 2, green → 3.

Availability indicators	Short definition / Full question	Value	Flag
AV-AC-3	Pricing  What is the cost basis ?	1. Not or not well documented	NO INFORMATION (red color)
		2. Commercial charge	CHARGE (orange color)
		3. Distribution charge	
		4. Free of charge for academic institutions and uses	
		5. Open and Free. No charge	NO CHARGE (green color)
Availability indicators	Short definition / Full question	Value	Flag
AV-AC-4	Data delivery mechanism  What services are available to the user to access data ?	1. No information was found on data delivery mechanisms	LOW ACCESSIBILITY (red color)
		2. Manual process: Order form/invoice is requested	MEDIUM ACCESSIBILITY (orange color)
		3. Online downloading services	
		4. Online discovery and downloading services	HIGH ACCESSIBILITY (green color)
		5. Online discovery + downloading + viewing services (Advanced services) 5. Online discovery + downloading + viewing services (Advanced services) 5. Online discovery + downloading + viewing services (Advanced services)	
Availability indicators	Short definition / Full question	Value	Flag
AV-AC-5	Readiness of format for use  How ready is the format for operational use ?	1. Format not or not well documented	NOT READY TO BE CONSUMED (red color)
		2. Proprietary format and not well documented	
		3. Format not proprietary but content not clearly specified	
		4. Format proprietary but content clearly specified	CAN BE PROCESSED TO BE CONSUMED (orange color)
		5. Format not proprietary and content clearly specified (e.g. autodescription like ODV, NetCDF CF) or at least with appropriate document describing the content	READY TO BE CONSUMED (green color)
Availability indicators	Short definition / Full question	Value	Flag
AV-PE-1	Responsiveness	1. No information is found on response time	LOW RESPONSE (red color)
		2. More than 1 week for release	MEDIUM RESPONSE (orange color)
		3. Less or equal to 1 week for release	
		4. Online downloading (i.e. a few hours or less) for release	HIGH RESPONSE (green color)

Figure 4 Checkpoint availability indicators, part b)

Scores assigned to the characteristic availability indicators for “ship routing” are reported in Table 3, together with a reference to the source information used in the assessment. Furthermore, both characteristic-mean and indicator-mean scores are computed. The sole not full score (2 out of 3) arises from the data policy of all characteristics but the shoreline. This is due the fact that access to the data is possible upon registration, while for the GSHHG shoreline access is totally unrestricted.

**Table 3 Availability indicators for the characteristics of the Upstream Data employed for the application challenge “ship routing hazard maps”. Numbers in the superscripts refer to the information sources listed in the footnotes.**

	AV-VI-1	AV-VI-2	AV-AC-1	AV-AC-2	AV-AC-3	AV-AC-4	AV-AC-5	AV-PE-1	mean
<b>Characteristic</b>	<b>Easily found</b>	<b>EU catalogue service</b>	<b>visibility of data policy</b>	<b>Data policy</b>	<b>Pricing</b>	<b>Data Delivery mechanism</b>	<b>Readiness of format for use</b>	<b>Responsiveness</b>	
Shoreline	3 <sup>1</sup>	3 <sup>2</sup>	3 <sup>3</sup>	3	3	3	3	3	3.0
Bathymetry	3 <sup>4</sup>	3	3 <sup>5</sup>	2	3	3 <sup>6</sup>	3	3	2.9
Eastward surface current velocity	3 <sup>7</sup>	3 <sup>8</sup>	3 <sup>9</sup>	2	3	3 <sup>10</sup>	3	3	2.9
Northward surface current velocity	3 <sup>7</sup>	3 <sup>8</sup>	3 <sup>9</sup>	2	3	3 <sup>10</sup>	3	3	2.9
significant wave height	3 <sup>7</sup>	3 <sup>8</sup>	3 <sup>9</sup>	2	3	3 <sup>11</sup>	3	3	2.9
wave direction	3 <sup>7</sup>	3 <sup>8</sup>	3 <sup>9</sup>	2	3	3 <sup>11</sup>	3	3	2.9
wave peak period	3 <sup>7</sup>	3 <sup>8</sup>	3 <sup>9</sup>	2	3	3 <sup>11</sup>	3	3	2.9
mean	3	3	3	2.1	3	3	3	3	2.9

List of information sources for the availability indicators:

1 - <http://www.soest.hawaii.edu/wessel/gshhg/>

2 - <https://www.europeandataportal.eu/data/en/dataset/b4ccf943-4931-46e7-8cbc-0e806473f215>

3 – under GNU Lesser General Public License

4 - [https://www.gebco.net/data\\_and\\_products/gridded\\_bathymetry\\_data/](https://www.gebco.net/data_and_products/gridded_bathymetry_data/)

5 - [https://www.gebco.net/about\\_us/contributing\\_data/](https://www.gebco.net/about_us/contributing_data/)

6 - [https://www.gebco.net/data\\_and\\_products/imagery/](https://www.gebco.net/data_and_products/imagery/)

7 - <http://marine.copernicus.eu/services-portfolio/access-to-products/>

8 - <https://insitu.copernicus.eu/news/workshop-inspire-implementation-and-copernicus-services-data-access>

9 - <https://www.bho-legal.com/en/copernicus-data-policy/>

10 - [http://marine.copernicus.eu/services-portfolio/access-to-products/?option=com\\_csw&view=details&product\\_id=GLOBAL\\_ANALYSIS\\_FORECAST\\_PHY\\_001\\_024](http://marine.copernicus.eu/services-portfolio/access-to-products/?option=com_csw&view=details&product_id=GLOBAL_ANALYSIS_FORECAST_PHY_001_024)

11 - [http://marine.copernicus.eu/services-portfolio/access-to-products/?option=com\\_csw&view=details&product\\_id=GLOBAL\\_ANALYSIS\\_FORECAST\\_WAV\\_001\\_027](http://marine.copernicus.eu/services-portfolio/access-to-products/?option=com_csw&view=details&product_id=GLOBAL_ANALYSIS_FORECAST_WAV_001_027)

### 4.1.2. Appropriateness indicators

The appropriateness is established through a set of quality indicators which were defined in Manzella *et al.* (2017):

- Horizontal Spatial coverage
- Vertical spatial coverage
- Temporal coverage
- Number of characteristics
- Horizontal Resolution
- Vertical Resolution
- Temporal Resolution

The assessment is carried out through the Sextant portal (<https://sextant.ifremer.fr/>). The distances in values of actual (UD) from the ideal (DPS) was computed. The distance represents the error of each quality element. Results, obtained through Sextant, are provided Tables 4-7 below. All Upstream Data characteristics are adequate, with respect to the indicators assessed.

**Table 4 Appropriateness of UD characteristic “bathymetry” assessed through Sextant.**

Measure ID	Name	UD value	Quality errors (%)	Indicator	DPS value	TDP value
UD.AP.1.1	Horizontal spatial coverage	361,100,000 km <sup>2</sup>	330	100	84,000,000 km <sup>2</sup>	55,000,000 km <sup>2</sup>
UD.AP.1.2	Vertical spatial coverage	20,000 m	135	100	8,500 m	8,500 m
UD.AP.1.3	Temporal coverage	1,825 days	67	67	1,095 days	365 days
UD.AP.3.1	Horizontal resolution	925 m	3	3	900 m	900 m

**Table 5 Appropriateness of UD characteristic “shoreline” assessed through Sextant.**

Measure ID	Name	UD value	Quality errors (%)	Indicator	DPS value	TDP value
UD.AP.1.1	Horizontal spatial coverage	361,100,000 km <sup>2</sup>	330	100	84,000,000 km <sup>2</sup>	55,000,000 km <sup>2</sup>
UD.AP.1.2	Vertical spatial coverage	20 m	0	0	20 m	20 m
UD.AP.1.3	Temporal coverage	1,825 days	67	67	1,095 days	365 days
UD.AP.3.1	Horizontal resolution	200 m	60	60	500 m	500 m

Table 6 Appropriateness of UD characteristic “ocean currents” assessed through Sextant.

Measure ID	Name	UD value	Quality errors (%)	Indicator	DPS value	TDP value
UD.AP.1.1	Horizontal spatial coverage	361,100,000 km <sup>2</sup>	330	100	84,000,000 km <sup>2</sup>	55,000,000 km <sup>2</sup>
UD.AP.1.2	Vertical spatial coverage	20 m	0	0	20 m	20 m
UD.AP.1.3	Temporal coverage	10,036 days	817	100	1,095 days	365 days
UD.AP.3.1	Horizontal resolution	1,337 m	93	93	18,800 m	18,800 m
UD.AP.3.3	Temporal resolution	1 days	0	0	1 days	1 days

Table 7 Appropriateness of UD characteristic “waves” assessed through Sextant.

Measure ID	Name	UD value	Quality errors (%)	Indicator	DPS value	TDP value
UD.AP.1.1	Horizontal spatial coverage	361,100,000 km <sup>2</sup>	330	100	84,000,000 km <sup>2</sup>	55,000,000 km <sup>2</sup>
UD.AP.1.2	Vertical spatial coverage	20 m	0	0	20 m	20 m
UD.AP.1.3	Temporal coverage	1,095 days	0	0	1,095 days	365 days
UD.AP.3.1	Horizontal resolution	1,337 m	99	99	111,120 m	111,198 m
UD.AP.3.3	Temporal resolution	0.125 days	88	88	1 days	1 days

## 4.2. Fitness for purpose of the TDP

For the assessment of TDP fitness for purpose, the appropriateness “territory” was considered. Related indicators are addressed in the following subsection.

### 4.2.1. Appropriateness indicators

The appropriateness is established through following quality indicators:

- Horizontal Spatial coverage
- Vertical spatial coverage
- Temporal coverage
- Number of characteristics
- Horizontal Resolution
- Vertical Resolution
- Temporal Resolution

They are assessed through the Sextant portal. The distance of actual (TDP) from the ideal (DPS) values is computed. The distance represents the error of each quality elements.

The information obtained through Sextant is provided in Tables 8-11.

For all TDP characteristics, the spatial and temporal coverage were found to be partially inadequate.

For spatial coverage, UD value corresponds to the global ocean surface. As DPS value we considered the size of the minimum box enclosing all ship track bundles. We then accounted for the fact that in the TDP we could compute just part (about 65%) of the routes (i.e. connections between couples of harbours) initially envisioned. This results in a TDP value for spatial coverage being 65% of the DPS value.

For temporal coverage, partial inadequateness was assigned because the DPS was specified to run routes in three different years (i.e. 2015, 2016 & 2017), and the TDP only includes routes in 2017.

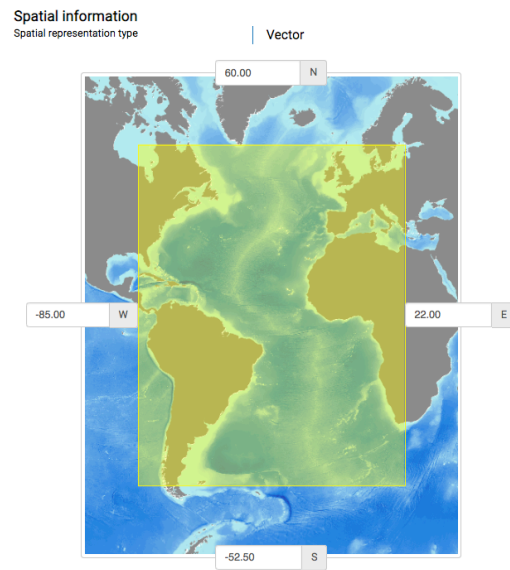


Figure 5 Spatial coverage for all TDP characteristics

Furthermore, for the characteristics “ocean currents” and “waves” in the TDP the horizontal resolution is near adequate. The DPS expected path resolution of 60 nautical miles (or 111,120 m) is quite close (within 1%) from the actual resolution achieved in the TDP (111,964 m).

Most TDP characteristics are adequate, with respect to the indicators. Thus, fitness for purpose of TDP is considered as fair.

Table 8 Appropriateness of TDP characteristic “bathymetry” assessed through Sextant; valid for both product component 1 and 2.

Measure ID	Name	TDP value	Quality errors (%)	Indicator	DPS value
TDP.AP.1.1	Horizontal spatial coverage	55,000,000 km <sup>2</sup>	-35	-35	84,000,000 km <sup>2</sup>
TDP.AP.1.2	Vertical spatial coverage	8,500 m	0	0	8,500 m
TDP.AP.1.3	Temporal coverage	365 days	-67	-67	1,095 days
TDP.AP.3.1	Horizontal resolution	900 m	0	0	900 m



Table 9 Appropriateness of TDP characteristic “shoreline” assessed through Sextant; valid for both product component 1 and 2.

Measure ID	Name	TDP value	Quality errors (%)	Indicator	DPS value
TDP.AP.1.1	Horizontal spatial coverage	55,000,000 km <sup>2</sup>	-35	-35	84,000,000 km <sup>2</sup>
TDP.AP.1.2	Vertical spatial coverage	20 m	0	0	20 m
TDP.AP.1.3	Temporal coverage	365 days	-67	-67	1,095 days
TDP.AP.3.1	Horizontal resolution	500 m	0	0	500 m

Table 10 Appropriateness of TDP characteristic “ocean currents” assessed through Sextant; valid for both product component 1 and 2.

Measure ID	Name	TDP value	Quality errors (%)	Indicator	DPS value
TDP.AP.1.1	Horizontal spatial coverage	55,000,000 km <sup>2</sup>	-35	-35	84,000,000 km <sup>2</sup>
TDP.AP.1.2	Vertical spatial coverage	20 m	0	0	20 m
TDP.AP.1.3	Temporal coverage	365 days	-67	-67	1095 days
TDP.AP.3.1	Horizontal resolution	111,964 m	-1	-1	111,120 m
TDP.AP.3.3	Temporal resolution	1 days	0	0	1 days

Table 11 Appropriateness of TDP characteristic “waves” assessed through Sextant; valid for both product component 1 and 2.

Measure ID	Name	TDP value	Quality errors (%)	Indicator	DPS value
TDP.AP.1.1	Horizontal spatial coverage	55,000,000 km <sup>2</sup>	-35	-35	84,000,000 km <sup>2</sup>
TDP.AP.1.2	Vertical spatial coverage	20 m	0	0	20 m
TDP.AP.1.3	Temporal coverage	365 days	-67	-67	1095 days
TDP.AP.3.1	Horizontal resolution	111,964 m	-1	-1	111,120 m
TDP.AP.3.3	Temporal resolution	1 days	0	0	1 days

### 4.3 Expert assessment

In order to make the outcome of all application challenges in AtlantOS WP8 comparable, a few summary questions (from Pinardi *et al.* 2017) were addressed, and are based on the quantitative results reported in Sect. 4.1-2 above.

1. The overall product quality score with respect to “fitness for purpose”:  
**“Good”**

This is based on the fact that 60% of the quality elements in the fitness for purpose assessment were in the green region by the Sextant software (see Table 12).

**Table 12** Scale used to determine "Fitness for purpose and use" of the Targeted Product (i.e. the HAB bulletin)

Score	Result	"Fitness for purpose and use" of the Targeted Product
1	EXCELLENT	completely meets the scope of the Targeted Product
2	VERY GOOD	meets > 70 % of Targeted Product scope
3	GOOD	meets < 50 % of the Targeted Product scope
4	SUFFICIENT	does not really meet the scope but it is a starting point
5	INADEQUATE	does not really fulfil the scope and is not usable

2. Most important characteristics for the Targeted Product quality:

**All characteristics** (shoreline, bathymetry, waves and currents) **are equally important.**

3. Quality element of the most important characteristics (variables) that affects the Targeted Product:

**Spatial resolution** and **temporal coverage** negatively affect the final score of the TDP (cf. Sect. 4.2)

4. Limitations of the quality of the targeted products due to input dataset:

**None** (cf. Sect. 4.1)

5. Characteristics that fail to meet the scope of the targeted product:

**None** (cf. Sect. 4.1)

6. Expert judgement of the most important gaps in the input data sets for the Targeted Product:

**None** (cf. Sect. 4.1)

## 5. Conclusions

Assessment results of both targeted products developed for the AtlantOS ship routing challenge show that:

- a) Both territorial indicators score high for the Upstream Data (UD). A score of 3 out of 3 is awarded for nearly all availability and appropriateness indicators, i.e., “green” level results in the Sextant software. A “green” level of fitness is thus awarded to the UD;
- b) The Targeted Data Product (TDP) developed in AtlantOS is to a very large extent adequate. Appropriateness is awarded a “green” level result in the Sextant software for most quality elements and characteristics. A partial inadequateness arises from a somewhat reduced spatial and temporal coverage of the products with respect to the Data Product Specification (dream product). This leads to an overall “yellow” fitness for purpose of the TDP on ship routing product developed in AtlantOS.

This outcome is summarised by the fitness “traffic lights” shown in Figure 6.

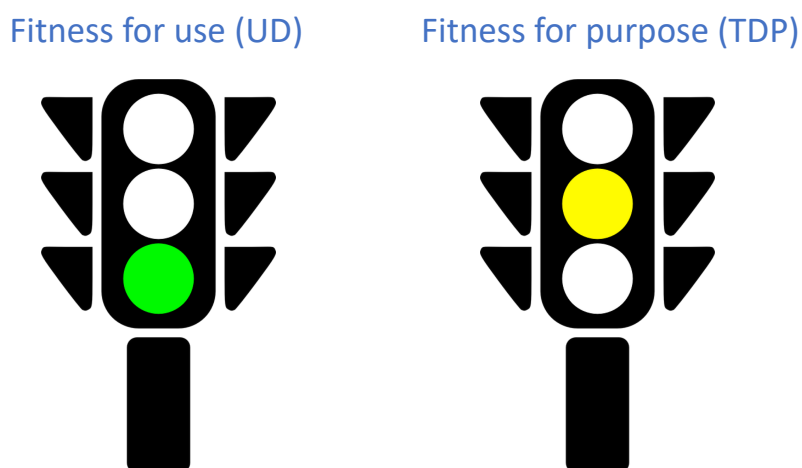


Figure 6 Synthetic outcome of the assessment of fitness for use of the Upstream Data and fitness for purpose of the Targeted Data Product for the ship routing products realised in AtlantOS Task 8.3.

Furthermore, six standard questions were answered in Sect.4.3 by expert assessment of Task 8.3’s products and was found to be comparable to the assessment of other application challenges in AtlantOS WP8.

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