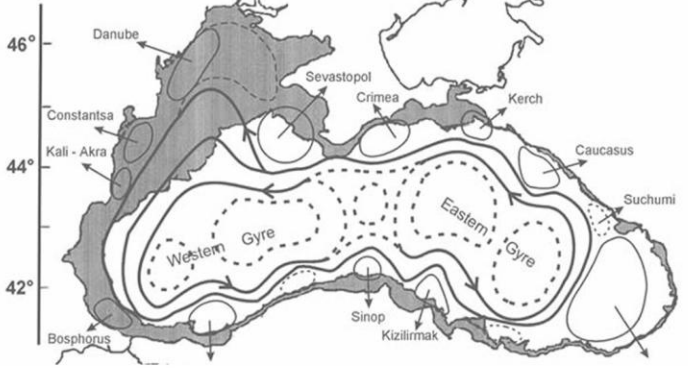

EMODnet Black Sea Checkpoint
Data Adequacy Report

EMODnet
European Marine Observation and Data Network

Black Sea Checkpoint

http://emodnet-blacksea.eu

Black Sea Checkpoint
Second Data Adequacy Report

Total number of pages: 82

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Glossary

2AR	Second Report on the Adequacy of the Global Climate Observing System for Climate
ADCP	Acoustic Doppler current profiler
AG FOMLR	Advisory Group on Environmental Aspects of Management of Fisheries and Other Marine Living Resources
AREG	Adriatic Sea regional model
ASAR	Advanced Synthetic Aperture Radar
ASCII	American Standard Code for Information Interchange
AQUASTAT	FAO's global information system on water and agriculture
ARGO	The broad-scale global array of temperature/salinity profiling floats
BGODC	Bulgarian National Oceanographic Data Centre
BfG	German Federal Institute of Hydrology (Bundesanstalt für Gewässerkunde), Germany
BODC	British Oceanographic Data Centre
BSC	Black Sea Commission
BSERP	Black Sea Ecosystem Recovery Project
BSIS	Black Sea Information System
CAF	Committee of Administration and Finance
CARLIT	Cartography of littoral rocky-shore communities
CAQ	Committee on Aquaculture
CDI	Common Data Index
CDOM	Colored dissolved organic matter
CDS	Catalogue of Data Sources
CFP	Common Fisheries Policy
CFRI	Central Fisheries Research Institute, Trabzon, Turkey
CH	Challenge – Check point application area
Characteristic	Distinguishing feature[1]
CI	Citation
Class	Description of a set of objects that share the same attributes, operations, methods, relationships, and semantics [UML Semantics] NOTE: A class does not always have an associated geometry (e.g. the metadata class).
CLS	Collecte Localisation Satellites (FR)
CLU	CLU s.r.l. (IT)
CMEMS	Copernicus Marine Environment Monitoring Service
CMS	Content management System
CoC	Compliance Committee
Copernicus	European Programme for the establishment of a European capacity for Earth Observation
Coverage:	a feature that has multiple values for each attribute type, where each direct position within the geometric representation of the feature has a single value for each attribute type[2]. Coverage is an abstraction of continuous real world phenomena[3].
COST	Cooperation in Science and Technology
CSR	Cruise Summary Report
CSW	Catalogue Service for Web
CTD	Conductivity, Temperature, Depth
DAC	Data Assembly Center
DAR	Data Adequacy Report
Data	Re-interpretable representation of information in a formalized manner suitable for communication, interpretation, or processing[4]

[1] ISO 9000:2005 Quality management systems. Fundamentals and vocabulary

[2] Quality/FDIS 19123 2005 Geographic information – Schema for coverage geometry and functions

[3] S. Nativi, J.Caron, B.Domenico and L.Bigagli, 2008. Unidata's Common Data model mapping to the ISO 19123 Data Model, Earth Sc. Informatics, Vomule 1,Issue 2, pp 59–78

DCF	Data Collection Framework
DCR	Data Collection Regulation
DCRF	Data Collection Reference Framework
DG-MARE	Directorate-General for Maritime Affairs and Fisheries
DEM	Digital Elevation models
DO	Dissolved oxygen
DPS	Data Product Specification[5]
DQ	Data quality
DTM	Digital Terrain Model
EAFM	Ecosystem-based approach to fisheries management
EC	European Commission
ECMWF	European Centre for Medium-Range Weather Forecast
ECVs	Essential Climate Variables
EDIOS	European Directory of Oceanographic Observing Systems
EDMED	European Directory of Marine Environmental Data
EDMERP	European Directory of Marine Environmental Research Projects
EDMO	European Directory of Marine Organisations
EEA	European Environmental Agency
EEC	European Economic Community
EEZs	Exclusive Economic Zones
EIONet	European Environment Information and Observation Network
EMBRC	European Marine Biological Resource Centre
EMODnet	European Marine Observation and Data Network
EMSA	European Maritime Safety Agency
EMSO	European Multidisciplinary Seafloor and water-column Observatory
ERIC	European Research Infrastructure Consortium
ESA	European Space Agency
ESFRI	European Strategy Forum on Research Infrastructures
ETC	European Topic Centre
EU	European Union
EUMETNET	European National Meteorological Services
EUNIS	European Nature Information System
EUROGOOS	European Global Ocean Observing System
FAO	Food and Agriculture Organization
Feature	Abstraction of real world phenomena. Discrete world phenomena are conceived as (discrete) features while continuous phenomena are conceived as features that “acts as a function to return values from its range for any direct position within its spatial, temporal or spatiotemporal domain (e.g., grids or images) named coverages[2]
Feature’s attribute	Characteristic of a feature
FixO3	Fixed point Open Ocean Observatory network
Fondazione CMCC	Foundation Euro-Mediterranean Center for Climate Change (IT)
GEBCO	General Bathymetric Chart of the Oceans
GEMET	General Multilingual Environmental Thesaurus[6]
GEMS	Global Environment Monitoring System
GES	Good Environmental Status
GEO	Group on Earth Observation
Geoportal	Type of web portal used to find and access geographical information
GEOSS	Global Earth Observation System of Systems
GeoTIFF	Public domain metadata standard
GFCM	General Fisheries Commission for the Mediterranean
GIS	Geographic information system
GMES	Global Monitoring for Environment and Security
GOOS	Global Ocean Observing System

[4] ISO/IEC 2382-1:1993 Information technology – Vocabulary – Part 1: Fundamental terms
[5] ISO 19131:2007/Amd 1:2011 Requirements relating to the inclusion of an application schema and feature catalogue and the treatment of coverages in an application schema
[6] Marine Metadata Interoperability Project - GEMET - GEneral Multilingual Environmental Thesaurus http://marinemetadata.org/references/gemet

GPRS	General Packet Radio Service
GPS	Global Positioning System
GRDC	Global Runoff Data Centre
GTS	Greenwich Time Signal
ICZM	Integrated Coastal Zone Management
IEC	International Electrotechnical Commission
IFR	Institute of Fishing Resources, Varna, Bulgaria
IFREMER	Institut Français de Recherche pour l'Exploitation de la Mer (FR)
IHO	International Hydrographic Organization
IMO	International Maritime Organization
IMP	Integrated Maritime Policy
IMS	Middle East Technical University Institute of Marine Sciences (TR)
Information	Knowledge concerning objects, such as facts, events, things, processes, or ideas, including concepts, that within a certain context has a particular meaning[4]
INSPIRE	Infrastructure for Spatial Information in the European Community[7]
IO-BAS	Institute of oceanology, Bulgarian Academy of Sciences (BG)
IOC	Intergovernmental Oceanographic Commission
IPCC	Intergovernmental Panel on Climate Change
IR	Infrared
ISO	International Organization for Standardization
ISO IEC	ISO International Electrotechnical Commission
ISO NP	ISO New Proposal
ISO NP TS	ISO NP Technical Specification
IT	Information Technology
IUU	Illegal, Unreported and Unregulated
JCOMM	Joint WMO-IOC Commission on Marine Meteorology
JECMAP	Joint European Coastal Mapping Programme
JRC	Joint Research Centre
KTU-MSF	Black Sea Technical University, Marine Science Faculty, Trabzon, Turkey
LAT	Lowest Astronomical Tide
LE	Lineage extended
LI	Lineage
LWN	Normalized water leaving radiance
LiDAR	3D laser scanning
MARBOUND	Maritime Boundaries Geodatabase
MD	Metadata
MedSea	Mediterranean Sea
MERCATOR	French center for analysis and forecasting of the global ocean
MMI	Marine Metadata Initiative/Marine Metadata Interoperability[8]
MPA	Marine protected areas
MRE	Marine renewable energy
MS	Member States
MSFD	Marine Strategy Framework Directive
MSP	Maritime Spatial Planning
MSSD	Mediterranean Strategy for Sustainable Development
MyOcean	Series of projects granted by the European Commission within the GMES Program (Seventh Framework Program)
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environmental Prediction
NEBS	North-Eastern Black Sea
NetCDF	Network Common Data Form
NeXOS	Next Generation Web-Enabled Sensors for the Monitoring of a Changing Ocean
NGO	Non-governmental organization

[7] Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE): http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32007L0002

[8] https://marinemetadata.org/

NIC	National Ice Center
NOAA	National Oceanic and Atmospheric Administration
NRT	Near Real Time
NKUA	National and Kapodistrian University of Athens (GR)
NIMRD	National Institute for Marine Research and Development "Grigore Antipa"(RO)
NWBS	North-Western Black Sea
Object	Entity with a well-defined boundary and identity that encapsulates state and behaviour [UML Semantics]. NOTE: An object is an instance of a class
ODV	Ocean Data View
OGC	Open Geospatial Consortium
ORION	Joint research and development centre (CY)
OSSE	Observing System Simulation Experiments
OSE	Observing System Experiment
OWF	Offshore Wind Farms
pH	Logarithmic measure of hydrogen ion concentration
P01	BODC Parameter Usage Vocabulary[9]
P02	SeaDataNet Parameter Discovery Vocabulary[10]
P03	SeaDataNet Agreed Parameter Groups[11]
P22	SeaDataNet GEMET - INSPIRE themes[12]
Package	Grouping of a set of classes, relationships, and even other packages with a view to organizing the model into more abstract structures
PNG	Portable network graphics
POMOS	Port Operational Marine Observing System
PR	Pre-eutrophication
PS	Post-eutrophication
PSMSL	Permanent Service for Mean Sea Level
PSU	Practical Salinity Units
QC	Quality Control
QE	Data quality extended
Quality	Degree to which a set of inherent characteristics fulfils requirements
Requirement	Need or expectation that is stated, generally implied or obligatory
RES	Renewable Energy Systems Limited (UK)
RFMO	Regional fisheries management organization
RivDIS	Global River Discharge data set
ROOS	Regional operational system
ROV	Remotely operated underwater vehicle
SAC	Scientific Advisory Committee
SAGE	Systems Approach to Geomorphic Engineering
SAR	Synthetic aperture radar
S-AWS	Ship-borne Automated Weather Stations
SCMR	SC Marine Research SRL (RO)
SeaDataNet/SDN	Pan-European infrastructure to ease the access to marine data measured by the countries bordering the European seas
SeaVoX	Combined SeaDataNet and MarineXML Vocabulary Content Governance Group
SID	Source identifier
SIO-RAS	P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences (RU)
Specification scope	Part of the data content of a product sharing the same specifications
SPLASHCOS	Submerged Prehistoric Archaeology and Landscapes of the Continental Shelf
SRTM	Shuttle Radar Topography Mission
SST	Sea Surface Temperature
SPOT	Commercial high-resolution optical imaging Earth observation satellite system operating from space
TDP	Targeted Data Products
STAG	Scientific and technical advisory group

[9] http://seadatanet.maris2.nl/v_bodc_vocab_v2/search.asp?lib=P01
[10] http://seadatanet.maris2.nl/v_bodc_vocab_v2/search.asp?lib=P02
[11] http://seadatanet.maris2.nl/v_bodc_vocab_v2/search.asp?lib=P03
[12] http://seadatanet.maris2.nl/v_bodc_vocab_v2/search.asp?lib=P22

STECF	Technical and Economic Committee for Fisheries
SWH	Significant wave heights
TSU	Ivane Javakhishvili Tbilisi State University (GE)
TAC	Total Allowable Catch
UkrSCES	Ukrainian Scientific Centre of Ecology of the Sea (UA)
UPL	Plymouth University (UK)
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
UNEP	United Nations Environment Programme
UNIDATA	Data Services and Tools for Geosciences[13]
UNESCO	United Nations Educational, Scientific and Cultural Organization
URL	Uniform Resource Locator
USE CASE	Exemplary literature case related to Challenge Targeted products
USOF	University of Sofia (BG)
UV	Ultraviolet
WISE	Water Information System for Europe
WBS	Western Black Sea
WFD	Water Framework Directive
WGBS	Working Group for the Black Sea
WMO	World Meteorological Organisation
VLIZ	Vlaams Instituut voor de Zee, Belgium
VMS	Vessel Monitoring System
VOS	Voluntary Observing Ships
XML	eXtensible Markup Language
YugNIRO	Southern Research Institute of Sea Fisheries and Oceanography, Kerch (RU)

[13] http://www.unidata.ucar.edu/

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Executive Summary

This second Black Sea Data Adequacy Report (DAR) concludes the development and implementation of the first assessment of basin monitoring gaps emergning from the generation of Targeted Data Products for 11 Challenges.

The methodology of the DAR follow closely the one developed for the Mediterranean Sea which is based upon ISO[14] and INSPIRE principles and the development of indicators. The indicators are constructed from the Black Sea Checkpoint metadatabase, which contains information on the upstream data used to construct the Challenge products. For each Challenge product, Checkpoint information on "What, Why, Where, When, How" data have been used to develop targeted products is given and statistically analysed.

The metadatabase contains 503 data set descriptors related to 42 characteristics, i.e. monitoring environmental and human activity information. These descriptors identify potentially usable information for the construction of the Challenge products. Targeted products were constructed from 253 input data sets for the fulfilment of the Challenge products.

The assessment methodology is providing quantitative and qualitative information on **How** the input data sets are made available to Challenges (Availability Indicators) and **What** is the quality of the monitoring data for the Challenge products (Appropriateness Indicators). The assessment methodology has been based on five elements:

1. the potential input data sets metadatabase and the availability indicators,
2. the Data Product Specification (DPS) and related quality elements,
3. the Targeted Data Products (TDP - requested by the call) information and the related quality elements;
4. the Ustream Data (UD) used for the products and the related quality elements,
5. the calculation of appropriateness indicators from the DPS, UD and TDP quality elements.

[14] Technical Committee ISO/TC 176 "Quality management and quality assurance" for ISO 9004 (Managing for the sustained success of an organization - A quality management approach)

Tecnical Committee ISO/TC 211, Geographic information/Geomatics for ISO19157 Geographic Information - Data Quality , ISO 19115 Geographic Information - Metadata, ISO 19131 Geographic Information - Data Product specifications...)

Indicator values have been grouped in three colour codes in order to increase the readability of the results.

Results are presented separately for the availability and appropriateness indicators and then they are combined to extract the monitoring gaps. Seventeen monitoring characteristics are found not adequate for the availability indicators (see Table 5.2.1 and Table 5.2.2). Six are instead found not adequate for appropriateness indicators (see Table 6.3 and 6.4) from the metadatabase analysis. However, it is believed that this evaluation was biased by the fact that the Data Product Specification was not really about what it should have been expected but more what was available. Thus we added the appropriateness scores coming from expert opinion and this raised the inadequate monitoring characteristics to 10 (Table 7.3.4).

In conclusion basin monitoring gaps emerging from the this analysis point out to 23 different characteristics that are not monitored adequately in order to construct the 11 Challenge products requested by DGMARE. They are listed in Table 9.1.

In synthesis the Black Sea Checkpoint demonstrated that a quality assessment framework can be defined for the marine environment at basin scales. The framework allows for the first time to assess the monitoring from a customized end-product user point of view. Recommandations for the future development of the service are given in the conclusions.

1. Introduction

The DG MARE tender "Sea basin checkpoints" asked to:

"…. examine the current data collection, observation, surveying, sampling and data assembly programmes in a sea basin, analyse how they can be optimised and deliver the findings to stakeholders…" with "the aim to assess how well all available marine data meets the needs of users".

The user needs are measured against the capacity to produce Targeted Data Products for 11 Challenges that are: CH1- Windfarm Siting, CH2- Marine Protected Areas, CH3- Oil Platform Leak, CH4- Climate, CH5-Coasts, CH6- Fishery Management, CH7- Fishery Impacts, CH8- Eutrophication, CH9- River Inputs, CH10- Bathymetry, CH11- Alien species.

This would enable:

- a clearer and innovative view of synergies between different marine monitoring, observation and data collection programs;
- an identification of how well the present data collection, monitoring and surveying programmes meet the needs of users or application Challenges;
- an identification of gaps;
- a view of where new technologies will allow faster, quicker and more accurate observation
- an understanding of required temporal or spatial resolution of data products such as bathymetry or marine sediments

During the implementation of Checkpoints, the concept of a Data Adequacy Report (DAR) was formulated as "a report providing a view of the monitoring effort in the sea basin" on the basis of expert opinions and quantifiyable quality elements, or indicators, related to 'availability' and 'appropriateness' of the input data sources. Scores for each quality element allow us to define the quality of the monitoring system.

In the framework of EMODnet Black Sea Checkpoint a Literature Survey[15] and a first DAR[16] have been released. The Literature Survey started to produce the Black Sea Checkpoint metadatabase containing information about potential input data sets for the generation of Targeted Data Products for the 11 Challenges and defined the "quality elements indicators". The first DAR was constructed with the data contained in the Black Sea Checkpoint metadatabase and an initial assessment of the input data adequacy in terms related to 'availability' quality elements was carried out.

The second DAR is completing the assessment using an updated first DAR metadatabase, and the 11 Challenge Targeted Data Products . This time the DAR will assess the 'appropriateness' in addition to 'availability' of the monitoring data sets used to produce the Challenge outputs. It will allow the final gap analysis and it will conclude with a list of potential improvements.

[15] http://emodnet-blacksea.eu/wp-content/uploads/2016/10/D1.3_LiteratureSurvey-BlackSeaCheckpoint.pdf

[16] https://webgate.ec.europa.eu/maritimeforum/system/files/BLACKSEA%20D15.2%20First%20Data%20Adequacy%20Report.pdf

1.1 The Challenge Targeted Products

DGMARE defined the following specific Targeted Data Products:

- CH1 – Windfarm siting
  - Suitability of sites for development of a wind farm
  - Appropriateness for a floating or fixed wind farm
- CH2 - Marine Protected Areas
  - Representativeness and coherency of existing European network of marine protected areas (national and international sites) as described in article 13 in the Marine Strategy Framework Directive.
- CH3 – Oil Platform leak
  - Likely trajectory of the slick and the statistical likelihood that sensitive coastal habitats or species or tourist beaches will be affected within 24 hours and after 72 hours
- CH4 – Climate
  - Spatial data layers for the following parameters for the past 5, 10, 50 and 100 years
    - average annual change in temperature at surface, mid- water and sea-bottom;
    - limits of extent of sea ice coverage
  - Time plots for the following parameters for the whole sea basin
    - average annual sea temperature over sea-basin at surface, mid-water column and bottom;
    - average annual changes in internal energy of sea;
    - years of appearance and where possible total ice cover in sea over past 100 years;
    - range of three most abundant species of phytoplankton
- CH5 – Coast
  - Spatial data layers for the following parameters for the past 10, 50 and 100 years
    - average annual sea-level rise at the coast (absolute and relative to the land);
    - annual sediment mass balance (mass gained or lost per stretch of coast)
  - Tables for the following parameters per stretch of coast:
    - average annual sea-level rise (relative to the land along the coast) for the past 10, 50 and 100 years
    - annual sediment balance along the Black Sea coast
- CH6 – Fishery Management
  - Tables for the whole sea-basin for
    - mass and number of landings of fish by species and year
    - mass and number of discards and bycatch (of fish, mammals, reptiles and seabirds) by species and year
- CH7 – Fishery Impact
  - Spatial data layers (gridded) showing the extent of fisheries impact on the sea floor
    - area where bottom habitat has been disturbed by bottom trawling (number of disturbances per month)
    - change in level of disturbance over past ten years
    - damage to sea floor to both living and non-living components
- CH8 – Eutrophication
  - Data layers (gridded) showing

        - seasonal averages of eutrophication in the basin for past 10 years
        - change in eutrophication over past ten years (i.e. where eutrophication has reduced and where it has increased)
- CH9 – River inputs
    - For each river bordering the sea basin, time series of annual inputs to sea of
        - water (mass and average temperature)
        - sediment
        - total nitrogen
        - phosphates
        - salmon (both inwards and outwards)
        - eels (both inwards and outwards)
- CH10 – Bathymetry
    - Sea basin digital map of
        - water depth
        - contour map of water depth for sea basin in vector format in interval of 100 m including coastline
        - priority areas for surveying for safer navigation taking into account emerging needs
        - uncertainty in water depth for Black sea basin.
- CH11 – Alien Species
    - Table and digital map of alien species in the sea basin
        - species name
        - family (fish, algae, mammals, sponges etc)
        - year of introduction
        - season for introduction (climate change, ballast water discharge etc)
        - geographical area
        - impact on ecosystem
        - impact on economy

These specifications have been transformed by each Challenge into “Targeted Data Products” with well-defined input datasets. A metadata archive has been developed where quality elements have been defined and assigned to both the Targeted Data Products and the input datasets. The assessment is done on the basis of indicators extracted from the metadata base or calculated from the metadata base information. This assessment framework is described in the next section.

1.2 The assessment framework

The overall aim of the EMODnet Checkpoints is to assess the adequacy of existing monitoring systems and data mechanisms at sea basin level. The scope is not primarily to test the effectiveness of EU initiatives, although this analysis should be included, but rather to assess how well all available marine data meet the needs of users or what else should be needed, at the scale of the EU seas and through the prism of downstream use cases called challenges.

To answer these questions, the sea basin checkpoint service has defined **a wide monitoring system assessment activity** aiming to support the sustainable Blue Growth at the scale of the

European Sea Basins and 6 regional checkpoints implemented (Arctic, Atlantic, Baltic, Black Sea, MedSea, North Sea) with a view to:

- **Clarify the observation landscape**, of all compartments of the marine environment – Air, Ice, Fresh Water, Marine Water, Riverbed/Seabed, Biota/Biology and Human activities -, pointing out to the existing programs, European, National, and International;
- **Evaluate the adequacy of marine data** that is how well the present data collection, monitoring and surveying programmes meet the needs of user, through the prism of blue applications of paramount importance for the European Marine Environment Strategy:
    - **Energetic and food security** (renewable energy, fisheries & aquaculture management);
    - **Marine environment variability and change** (climate change, eutrophication, river inputs, bathymetry, alien species);
    - **Emergency management** (oil spills, fishery impacts, coastal impacts);
    - **Preservation of natural resources and biodiversity** (connectivity of Marine Protected Areas).
- **Identify gaps in data and service infrastructure** for selected use cases, called challenges, including the reluctance to use;
- **Identify the needs to optimize existing monitoring systems** in terms of availability, operational reliability, efficiency, time consistency, space consistency, etc., **as well as observational priorities required in the future to meet the challenges.**

The Black Sea Checkpoint adopted and adapted the new developed Mediterranean Sea Checkpoint framework to carry out the data adequacy assessment. This framework is based upon three methodological pillars:

1) use of the ISO principles for the methodological development and the metadata definition;
2) design of a metadata base containing the information about the input data sets, the Targeted products and the quality indicators;
3) definition of indicators for the objective assessment of the data adequacy following INSPIRE rules.

The Black Sea Checkpoint uses, as communication standards, the SeaDataNet Vocabularies which includes the INSPIRE spatial themes.

The SeaDataNet Vocabulary adopts a hierarchical approach for the classification of terms:

1. Agreed Parameter Groups (P03) - Terms agreed within the EU SeaDataNet community to describe coarse-grained groupings of related measurement phenomena,
2. Parameter Discovery Vocabulary (P02) Terms describing fine-grained related groups of measurement phenomena designed to be used in dataset discovery interfaces,
3. Parameter Usage Vocabulary (P01) - Parameter semantic model designed to describe individual measured phenomena.
4. GEMET - INSPIRE themes (P22) - Groupings of spatial data according to Annex I, II and III of the INSPIRE Directive [DS-D2.5]

This hierarchy goes from a coarser (P03) to a finer classification of a given dataset (P01).

The INSPIRE spatial themes are managed/governed by the Inspire geographic community of practices: web service GEMET (General Multilingual Environmental Thesaurus), 33 spatial themes described in (P22).

The overall working scheme of the Black Sea Checkpoint is shown in Figure 1.1.

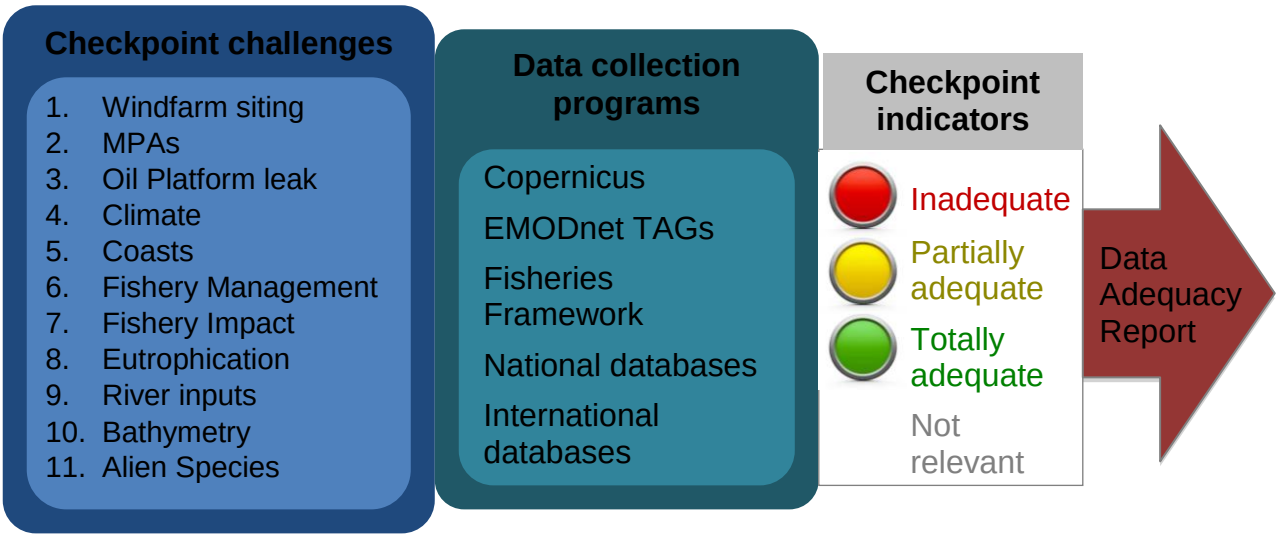


Fig. 1.1 The Black Sea Checkpoint Framework, from Upstream data to Checkpoint Service

1.3 Structure of the document

The report is subdivided into nine sections:

1) general introduction;
2) section describing the ISO and INSPIRE methodological framework used in the Checkpoint;
3) section describing the assessment indicators;
4) section describing the input data sets presently stored in the Checkpoint metadatabase;
5) section with the analysis the input data sets in terms of availability indicators;
6) section with the analysis the input data sets in terms of appropriateness indicators;
7) section with the analysis of the Targeted product quality by expert evaluation;
8) section with the gaps from the combined analysis of the two indicators;
9) conclusions and recommendations.

Five Annexes are part of the second DAR:

Annex 1:	Statistical analysis of the input data sets in the metadatabase and the vocabulary definitions
Annex 2:	The indicator definitions,
Annex 3 & Annex 4:	Statistical analysis of indicators,
Annex 5:	Expert opinions on the Challenge products and gaps.

2. The Data Adequacy assessment methodology

An objective assessment of the existing data quality and their 'usability' for Challenge products should be based on selected ISO standards which provide the methodology, definitions and quality elements used to establish indicators. The general framework has been provided by the "Methodology to assess and communicate the economic benefits of consensus-based standards"[17] developed by ISO.

2.1 Key definitions

In the Literature Review for the Black Sea Checkpoint, following the Mediterranean Checkpoint work, important efforts were made to provide definitions based on ISO standards.

- **Characteristic:** a distinguishing feature which refers:
  - either to a variable derived from the observation, the measurement or the numerical model output of a phenomenon or of an object property in the environment;
  - or to the geographical representation of an object on a map (ie a layer such as a protected area, a coastline or wrecks) by a set of vectors (polygon, curve, point) or a raster (a spatial data model that defines space as an array of equally sized cells such as a grid or an image).

- **Environmental matrices:** The environments where characteristics are measured or computed:
  - Ice,
  - Air,
  - Fresh water,
  - Marine water,
  - Biota/Biology,
  - Riverbed/Seabed,
  - Human activities.

- **Data:** reinterpretable representation of information in a formalized manner suitable for communication, interpretation or processing (ISO 19115)
- **Dataset:** an identifiable collection of data (ISO 19115). It can be a time series, a lithological description of a marine sample, a gridded dataset such as a DTM, an hydrodynamic model output, a GIS dataset or a feature layer of a GIS dataset, a data base or a table of values in a publication. A dataset can be constituted of several files (e.g. the set of seismic data files recorded along the same line**).**
- **Collection of datasets:** a set of datasets.

[17] Assessing economic benefits of consensus-based standards – The ISO methodology. https://www.iso.org/sites/materials/benefits-of-standards/benefits-detail57da.html?emid=6

- **Dataset series:** a collection of datasets sharing the same specifications of production. This is the concept in use on the INSPIRE Geoportal.
- **Input Dataset:** the collection of existing data to be input to the Challenges
- **Assessment criteria:** the criteria are focused on two questions: "what" is made available to the challenges and 'how'. Appropriateness (what) and availability (how) indicators were defined using ISO 19157 standards.
- **Data adequacy:** can be defined as the fitness for use of the data for a particular user or for a variety of users. Since different applications require different properties associated with the data itself, 'adequacy' should be defined objectively using standardized nomenclature and methods. In an EC Report[18] adequacy was defined as an assessment of the reported information to meet the objectives of the Marine Strategy Framework Directive (MSFD) and its technical requirements listed in MSFD Articles 8, 9 and 10[19]. The Checkpoint adequacy is close to this definition but focused on several Challenges. In other words, **adequacy** is here intended as 'sufficient to satisfy a requirement or meet a need'[20]. From this definition, 'adequacy' relates to meeting both requirements as well as needs and is normally applied within the framework of an ISO 9001 based Quality Management System.

2.2 The Checkpoint assessment: ISO and INSPIRE concepts

The aim of the Checkpoints is to assess the adequacy of the monitoring or data collection strategy at the European basin scale level under specified operational conditions (represented by the Challenges). 'Adequacy' thus relates to meeting both requirements as well as needs of the users and is normally defined within the framework of an ISO 9001 based Quality Management System.

The assessment methodology is based on four elements:

1. the Data Product Specification,
2. the collection of information on Input Data needed for these products,
3. the realization of Targeted Data Products (TDP - requested by the call) using the Input Data
4. the development of indicators to assess Input Data and the adequacy of products obtained from them with respect to DPS.

Data Product Specifications

A Data Product Specification (DPS) is a detailed description of a dataset or dataset series together with additional information that will enable it to be created, supplied to- and used

[18] The first phase of implementation of the Marine Strategy Framework Directive (2008/56/EC) - The European Commission's assessment and guidance. CELEX_52014SC0049_EN_TXT

[19] Adequacy does not necessarily mean, for instance, that if the defined data is adequate, this automatically means that the quality of the marine waters Is acceptable

[20] Random House Unabridged Dictionary, Random House Inc, 2006

by- another party (ISO19131:2007). It is a precise technical description of the data product in terms of the requirements that it will or may fulfil. The data product specification only defines how the dataset should be and provide the basis for the assessment of the Upstream Data sets supplied to- and used by- the challenges for the Targeted Data Products (TDP).

Upstream data sets

The initial effort of the Black Sea Checkpoint was the collection of information related to input data sets potentially required by the Challenges. The selection of input data sets was derived from expert specifications of data needs for Challenge products required by the tender and listed in §1. The content of the Checkpoint metadatabase is then strongly linked to the specific Challenges chosen by the DGMARE call for tender and the expert opinion. Additional consultations in the challenge communities of practices have helped to finalise the list of data providers and data sets.

Targeted Data Products

The values of data increases when they are transformed in sophisticated Data Products (e.g. by means of analysis, models, etc.). Targeted Data Products can assist stakeholders with their specific decisions.

The ISO quality standard principles provide the model to assess the effectiveness of a monitoring system or data collection strategy, quality of data and quality of services that fits the user's defined requirements, under specified operational conditions (represented by the Challenges).

2.2.1. The ISO rules adopted for the assessment

The assessment methodology is derived from ISO9004-2009 standards, which are part of the ISO9000 series. These are based on principles that can be adapted to Checkpoints:

- Customer focus: understand current and future customer needs, should meet customer requirements and strive to exceed customer expectations.
- Factual approach to decision making: effective decisions are based on the analysis of data and information.
- Continual improvements: assessment of existing monitoring systems, improvements and overall performance should be a permanent objective of decision makers
- Mutually beneficial supplier relationships: data suppliers and data users are interdependent and a mutually beneficial relationship enhances the ability of both to create value.

ISO 9004:2009[21] provides organizations with a model for "sustained success" in today's complex, demanding, and ever-changing environment. This can be used to assess the quality of the products of the Challenges and the existing service delivery to stakeholders by:

- Benchmarking their level of quality
- Identify their strengths and weaknesses
- Identify opportunities for either improvements or innovation, or both.

The general framework for the assessment of the quality of products of Challenges and their input data sets has been provided by the "Methodology to assess and communicate the economic benefits of consensus-based standards"[22] developed by ISO. The quality elements that allow the objective assessment are provided mainly by the ISO 19157:2013(E) Data Quality and ISO 19115:2014(E) Metadata.

ISO19157:2013(E) provides the quality element that is called “usability”, i.e. the extent to which data sets or data set series can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use. In other words, ISO 19157 standards contain elements for assessing ‘how’ and ‘how much’ data meets requirements in order to enhance user satisfaction.

Whereas ISO 19131 provides the framework for data product specification, ISO 19115 and ISO 19119 the framework to describe input data and the associated service.

There are all parts of the ISO/TC211 suite of standards for geographic information[23].

The ISO standards used for definitions, assessment and services:

- ***Standards used for key definitions***

    - ISO9000: The ISO 9000 family addresses various aspects of quality management. The standards provide guidance and tools for companies and organizations who want to ensure that their products and services consistently meet customer’s requirements, and that quality is consistently improved.

    - ISO9001: sets out the requirements of a quality management system.

[21] ISO9004-2009. Managing for the sustained success of an organization. A quality management approach
[22] Assessing economic benefits of consensus-based standards – The ISO methodology. http://www.iso.org/iso/home/standards/benefitsofstandards/benefits-detail.htm?emid=6
[23] http://www.isotc211.org/Outreach/ISO_TC_211_Standards_Guide.pdf

- ISO19113: establishes the principles for describing the quality of geographic data and specifies components for reporting quality information. It also provides an approach to organizing information about data quality. This standard has been revised by ISO19157.

- ISO19131: help in the creation of data product specifications, so that they are easily understood and fit for their intended purpose.

- ***Standards used for assessment criteria***

  - ISO9004: focuses on how to make a quality management system more efficient and effective.

  - ISO19108: defines concepts for describing temporal characteristics of geographic information. It depends upon existing information technology standards for the interchange of temporal information.

  - ISO19157: establishes the principles for describing the quality of geographic data (components for describing data quality; components and content structure of a register for data quality measures; general procedures for evaluating the quality of geographic data; principles for reporting data quality). It also defines a set of data quality measures for use in evaluating and reporting data quality.

- ***Standards used for the Services***

  - ISO19115: defines the schema required for describing geographic information and services by means of metadata. It provides information about the identification, the extent, the quality, the spatial and temporal aspects, the content, the spatial reference, the portrayal, distribution, and other properties of digital geographic data and services. ISO19115-3 provides their XML schema implementation.

  - ISO 19156:2011 defines a conceptual schema for observations, and for features involved in sampling when making observations. These provide models for the exchange of information describing observation acts and their results, both within and between different scientific and technical communities.

- ISO19119: identifies and defines the architecture patterns for service interfaces used for geographic information, defines its relationship to the Open Systems Environment model, presents a geographic services taxonomy and a list of example geographic services placed in the services taxonomy.

2.2.2. The INSPIRE rules adopted for the services

To ensure that the spatial data infrastructures of the Member States are compatible and usable in a Community and transboundary context, the INSPIRE Directive requires that common Implementing Rules (IR) are adopted in a number of specific areas.
The INSPIRE guiding principles state that infrastructures for spatial information in the Member States should be designed to ensure:

1. that spatial data is stored, made available and maintained at the most appropriate level;
2. that it is possible to combine spatial data and services from different sources across the Community in a consistent way and share them between several users and applications;
3. that it is possible for spatial data collected at one level of public authority to be shared between all the different levels of public authorities;
4. that spatial data and services are made available under conditions that do not restrict their extensive use;
5. that it is easy to discover available spatial data, to evaluate their fitness for purpose and to know the conditions applicable to their use.

Main components of the INSPIRE directive:

- metadata,
- interoperability of spatial data and services,
- services (discovery, viewing, downloading, transformation and invoke),
- joint use of spatial data and services,
- coordination and supervision and reporting measures

As almost all the characteristics that are populating the Black Sea Checkpoint metadatabase are composed by spatial data, the INSPIRE needs and requirements have been translated partly in terms of indicators and they have been used to construct the Checkpoint services and to assess the “Adequacy” – throughout the ‘Availability’ and ‘Appropriateness’ - of the monitoring data sets used to produce the Challenge outputs

The technical specifications provided by INSPIRE metadata implementing rules: technical guidelines based on EN ISO 19115 and EN ISO 19119[24] are listed below:

[24] https://inspire.ec.europa.eu/documents/inspire-metadata-implementing-rules-technical-guidelines-based-en-iso-19115-and-en-iso-1

➢ Service to access to information: The INSPIRE Rule for accessing information are part of the ISO19115 On-line resource and INSPIRE Implementing Rules for Metadata B 1.4 – Resource Locator. The Resource Locator is the 'navigation section' of a metadata record which point users to the location (URL) where the data can be downloaded, or to where additional information about the resource may be provided. Setting up the correct resource locators is important for the connection between the data and the services that provide access to them or for providing additional information concerning the resource. If a linkage for data is available, the Resource Locator shall be a valid URL providing one of the following:

- a link to a web with further instructions
- a link to a service capabilities document
- a link to a client application that directly accesses the service

➢ Service to link datasets: In addition to the Resource Locator, it should be considered also the link of services to the relevant datasets, and this is the metadata element called Coupled Resources and referenced in B 1.6 of the Implementing Rules.

➢ Classification of characteristics: A correct categorisation of characteristics is very important to help users to search and find the resources they are looking for (Topic category, B2.1). For the purpose of the project, the SeaDataNet classification lists have been adopted for the following reasons:

- the vocabularies are governed by a Governance Group ensuring the vocabulary is consistent with the needs and the practices of the marine community through time;
- they are designed for discovery services;
- the SDN classification hierarchy offers three different levels of granularity: the variables (SDN parameter list P01), the categories or characteristics (SDN P02 list) and the group of categories or group of characteristics (SDN P03 list) allowing to navigate from the more general level of information to the most detailed one. In addition, the INSPIRE themes are included in the P22 list.

➢ INSPIRE Network Service: The INSPIRE Implementing Rules requires also to specify if the discovery, view, download, transformation, invoke and other services are 'INSPIRE Network Services' (Spatial service type B 2.2).

➢ Conditions for access and use of spatial data sets and services, and where applicable, corresponding fees as required by Article 5(2)(b) and Article 11(2)(f) of INSPIRE Directive 2007/2/EC. These are part of B 8.1 Implementing Rules: Restrictions on the access and use of a resource or metadata. It is recommended to have in the metadata descriptions of terms and conditions, including where applicable, the corresponding fees or a link (URL) where these terms and conditions are described.

➢ The INSPIRE Implementing Rules defines the metadata concepts for limitations on public access in part B 8.2 that applies to access constraints to assure the protection of privacy or intellectual property, and any special restrictions or limitations on obtaining the resource. In relation to constraints classes, there may be three scenarios according to the INSPIRE rules:

- There may be no limitation on public access;
- There may be only a classification property when expressing a security constraint;
- There may be one or more instances of the access constraints property, possibly associated with one or more instances of other restrictions property (i.e, Legal Constraints).

3. The Checkpoint assessment indicators

The assessment criteria have subdivided into two 'Territories' that need to be evaluated in terms of Challenge requirements. The term "territory" refers to a domain of assessment and we have chosen two categories:

Territory 1: Availability **How** the input data sets are made available to Challenges
Territory 2: Appropriateness **What** is the quality of the monitoring data for the Challenge products

Table 3.1 The two territories of the assessment

3.1 Territory 1: Availability

"Availability" measures the extent to which datasets are ready for use and are obtainable. The eight availability indicators are:

Definitions	Name of Availability indicators
Visisbility Indicators	
Easy found	AV-VI-1
EU Inspire Catalogue service	AV-VI-2
Accessibility Indicators	
Policy visibility	AV-AC-1
Delivery	AV-AC-2
Data Policy	AV-AC-3
Pricing	AV-AC-4
Readiness	AV-AC-5
Performance Indicator	
Responsiveness	AV-PE-1

Table 3.1.1 Availability indicators nomenclature

The availability indicators (AV) provide an understanding of the readiness and service performance of the infrastructure providing access to data. The availability indicators are subdivided into three categories:

- Visibility (VI), i.e. the possibility of identifying and quickly accessing the appropriate site for the required data sets;
- Accessibility (AC) i.e. the possibility,for non expert users, to understand the retrieval model status;
- Performance (PE) i.e. the ability of a system to keep operating over time and to meet real time operational conditions.This is related to service performance.

3.1.1 Visibility indicators

"Visibility" is the ability to identify and quickly access the appropriate site delivering the desired data sets. In other words it is the ability for all users, including non-experts, to

perform data sourcing through an EU Inspire catalogue. Two indicators have been defined for the visibility element, i.e.:

AV-VI-1 Easily found	**Can the data sets or series of data sets be found easily?**
AV-VI-2 EU Inspire catalogue servic	Is the dataset referenced by a EU catalogue service or other bodies (private or public, national or international non EU services*)

Table 3.1.2 Visibility indicator meaning

By referring to the INSPIRE Directive, this AV-VI-1 indicator provides information on visibility of data in catalogues. The AV-VI-2 indicator informs users whether the characteristic can be searched for by a catalogue service, such as EMODnet Thematic Portals, Copernicus core services, EEA services, DG MARE services, INSPIRE Geoportal, etc. Both indicators are identified as part of the INSPIRE Metadata Implementing Rules B 1.4 and the technical guidelines are based on EN ISO 19115 and EN ISO 19119.

3.1.2 Accessibility indicators

'Accessibility' is the ability of all users, including non-experts, to understand the retrieval model status and its appropriateness. ISO 19115 provides a general mechanism for documenting different categories of constraints applicable to the resource (or its metadata). The constraints could be legal and/or security constraints.

The INSPIRE Implementing Rules defines the metadata concepts for limitations on public access in part B 8.2 that apply to access constraints in order to ensure the protection of privacy or intellectual property, and any special restrictions or limitations on obtaining the resource. In relation to constraint classes, there may be three scenarios according to the INSPIRE rules:

- There might be no limitation on public access;
- There might be only a classification property when expressing a security constraint;
- There might be one or more instances of the access constraints property, possibly associated with one or more instances of other restrictions property (e.g., Legal Constraints).

There are five indicators devised for accessibility:

AV-AC-1 **Policy visibility**	Visibility on data policy adopted by data providers
AV-AC-2 Delivery	Data delivery mechanisms, i.e. theservices available to the user to access data
AV-AC-3 Data Policy	Data policy
AV-AC-4 Pricing	Cost basis / price policy

AV-AC-5 Readiness	Format for use

Table 3.1.3 Accessibility indicator meaning

In the framework of the “blue growth” and for the specific indicator on Data policy, the exact meaning of ‘open’ has not been established. Among the many definitions of ‘open’, one or more of these can be adopted:

- Accessible to all; unrestricted to participants
- Free from limitations, boundaries, or restrictions
- Usable by registered users

The indicator will classify all of these under the same score value

3.1.3 Performance indicators

The performance indicators indicate the ability of a system to keep operating over time and to meet real time operational conditions. It is related to service performance.Only oneindicator is defined for performance:

AV-PE-1 Responsiveness	**How responsive is the delivery service for the available data?**

Table 3.1.4 Performance indicator meaning

3.1.4 Availability indicators evaluation scale

Indicators provide both an overview of the situation at a high level of aggregation as well as detailed information about trends and links. The difficult task is to find an appropriate balance between simplification and completeness and offer, at the same time, an assessment of the input data sets without directly accessing all the metadata. The Checkpoint has defined 4-6 possible values for the different availability indicators and has defined a “color scale” evaluation that is described in Annex 3, Table A3.0.

In synthesis the meaning of the color scale is:

Red: **urgent actions are required to provide datasets and services fitting for use – totally inadequate**

Yellow: **limited actions are required to provide datasets and services fitting for use – partly adequate**

Green: **actions and services are fit for use and should be maintained – fully adequate**

3.2 Territory 2: Appropriateness

Appropriateness indicators are constructed by comparing the DPS (Data Product Specification) Quality Elements against the TDP (Targeted Data Product) and UD (Upstream Data) quality elements. The concept is illustrated in Fig. 3.2.1

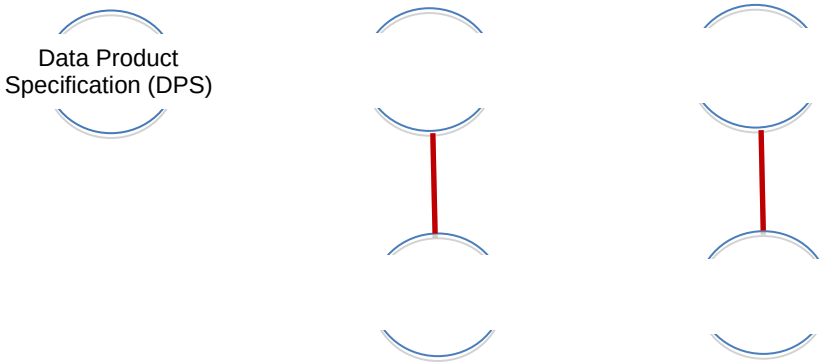


Figure 3.2.1 High level scheme for the appropriateness indicators: Quality Elements are decided for DPS and reproduced for TDPand UD so that a "difference" (TDP minus DPS or UD minusDPS) can be calculated and this gives indicator values.

In a generic assessment process the first step is the assessment of the appropriateness of TDP vs the product specification. In Checkpoint we add the assessment also of the UD with respect to product specification since we are interested to extract information about quality the quality of the monitoring system that provides input data to the products. The details of the calculations are given in Annex 2.

3.2.1 Quality elements for appropriateness

'Appropriateness' is providing indications on the inherent properties of the products and the input data sets used in the products. The quality elements are specified in ISO19157 standards. The relevant Appropriateness quantitative elements chosen for the Checkpoint are listed in Table 3.2.1.

Definitions	Name of Appropriateness Quality Elements
Completeness	
Horizontal Spatial Coverage	AP-1-1
Vertical Spatial Coverage	AP-1-2
Temporal Coverage	AP-1-3
Consistency	
Number of Characteristics	AP-2-1
Accuracy	
Horizontal Resolution	AP-3-1
Vertical Resolution	AP-3-2
Temporal Resolution	AP-3-3
Thematic Accuracy	AP-3-4
Temporal Quality	
Temporal Validity	AV-4-1

Table 3.2.1 Appropriateness quality elements nomenclature

In the Black Sea Checkpoint, appropriateness is measuring how input data sets are fit for the

challenges. The appropriateness quality elements, definitions, measures, units and calculation of the fitness for use are given in Annex 2 and are herewith shortly presented.

3.2.1.1 Completeness quality elements

'Completeness' is the amount or extent to which something is covered or data are absent from a data set. In the case of the check points the completeness applies to both spatial and temporal coverage. Three indicators have been defined as 'coverage'.

#-AP-1.1 Horizontal Spatial Coverage	Horizontal coverage extent of product (eg : surface of the Black Sea)
#-AP-1.2 Vertical Spatial Coverage	**Vertical coverage extent of product**
#-AP-1.3 Temporal Coverage	**Temporal coverage extent of product**

Table 3.2.2 Completeness quality elements meaning. The # is replaced in the metadatabase with DPS, TDP and UD as appropriate.

3.2.1.2 Consistency quality elements

'Consistency' is the adherence to rules of the conceptual schema and measures the uniformity among the parts of the Data Product Specification and Targeted Data Product. This quality element is only applicable to DPS and TDP.

#-AP-2.1 Number of Characteristics	Number of Characteristics in product

Table 3.2.3 Consistency quality element meaning. The # is replaced inthe metadatabase with DPS and TDP as appropriate.

3.2.1.3 Accuracy quality elements

'Accuracy' is the comparison of classes assigned to features or their attributes to universe of discourse or the extent to which a given measurement agrees with the standard value for that measurement. Three indicators on 'spatial and temporal resolution' and one indicator on 'thematic accuracy' have been used.

#-AP-3.1 Horizontal Resolution	Horizontal mesh size or equivalent value for the given scale of product (eg 50m for 1/50 000)
#-AP-3.1 Vertical Resolution	**Temporal sampling interval of product**
#-AP-3.2 Temporal Coverage	**Temporal coverage extent of product**
#-AP-3.3 Thematic Accuracy	**Percentage error of the product and description of error concept for the product**

Table 3.2.4 Accuracy quality elements meaning. The # is replaced in the metadatabase with DPS, TDP and UD as appropriate.

3.2.1.4 Temporal Quality element

'Temporal quality' is the validity of data with respect to time. This provide an indication on how old is the last update of the input data set and an indirect information on how much can be assumed

valid the product.

#-AP-4.1 Temporal Validity	Max elapsed time between last input data records update and product creation date

Table 3.2.5 Temporal quality element meaning. The # is replaced inthe metadatabase with DPS, TDP and UD as appropriate.

3.2.2 Appropriateness indicator definitions

The basic idea of appropriateness indicators is that they are related to “errors” in the Quality Elements just defined. Appropriateness corresponds then to “low” errors in the specific quality element.

“Errors” for quality elements are defined as the differences between what has been realized and what was “expected” or “required”. DPS includes the requirements or expectations while TDP and UD are the actual products and input data sets used respectively.

The nine appropriateness indicators for Targeted Data Products are described in Table 3.2.6.

QE number	Indicator Indicator name	Definition of indicator	Units
1	TDP.APE.1.1	Percentage to which the extent of the horizontal spatial coverage of TPD is compliant with the DPS extent in km**2	Percentage
2	TDP.APE.1.2	Percentage to which the extent of the vertical spatial coverage of TPD is compliant with the DPS extent in metres.	Percentage
3	TDP.APE.1.3	Percentage to which the extent of the temporal coverage of TPD is compliant withthe DPS extent in days.	Percentage
4	TDP.APE.2.1	Percentage of Completeness/Incompleteness of the number of characteristics with respect to the list in DPS.	Percentage
5	TDP.APE.3.1	Percentage to which the product averaged horizontal mesh size or horizontal scale is compliant with the DPS averaged mesh size or horizontal scale.	Percentage
6	TDP.APE.3.2	Percentage to which the product averaged vertical mesh size or vertical scale is compliant with the DPS averaged mesh size or vertical scale.	Percentage
7	TDP.APE.3.3	Percentage to which the product temporal sampling interval is compliant with the one defined in DPS (percentage to be extracted from text of AP.3.3 measure).	Percentage
8	TDP.APE.3.4	Compliance with the value domain of the accuracy defined in DPS	Percentage
9	TDP.APE.4.1	Percentage to which the elapsed time of the product is compliant with the max elapsed time specified in DPS.	Percentage

Table 3.2.6 Appropriateness indicators meaning for Targeted DataProducts. The indicators

that are based on calculation of"errors" for the different quality elements and they are explained in details in Annex 2.

Moreover the same type of indicators have been evaluated for the input data sets to the TDP and they are called UD indicators. The eight appropriateness indicators for Upstream Data are described in Table 3.2.7

QE number	Indicator Indicator name	Definition of indicator	Units
1	UD.APE.1.1	Percentage to which the extent ofthe horizontal spatial coverage of UD is compliant with the DPS extent in km**2	Percentage
2	UD.APE.1.2	Percentage to which the extent of the vertical spatial coverage of UD is compliant with the DPS extent in metres.	Percentage
3	UD.APE.1.3	Percentage to which the extent of the temporal coverage of UD is compliant withthe DPS extent in days.	Percentage
4	UD.APE.3.1	Percentage to which the product averaged horizontal mesh size or horizontal scale is compliant with the DPS averaged mesh size or horizontal scale	Percentage
5	UD.APE.3.2	Percentage to which the product averaged vertical mesh size or vertical scale is compliant with the DPS averaged mesh size or vertical scale	Percentage
6	UD.APE.3.3	Percentage to which the product temporal sampling interval is compliant with the one defined in DPS (percentage to be extracted from text of AP.3.3 measure)	Percentage
7	UD.APE.3.4	Compliance with the value domain of the accuracy defined in DPS	Percentage
8	UD.APE.4.1	Percentage to which the elapsed time of the product is compliant with the max elapsed time specified in DPS.	Percentage

Table 3.2.7 Appropriateness indicators meaning for Upstream Data.The indicators that are based on calculation of "errors" for thedifferent quality elements and they are explained in details in Annex 2.

3.2.3 Appropriateness indicators evaluation scale

In the case of appropriateness, it is less immediate than for availability to provide a simple characterization of the indicators at a high level of aggregation. At present we have made some simplifying assumptions, allowing a non-expert to easily assess the appropriateness indicators without looking at the metadata and reports.

Appropriateness indicator values for both TDP and UD can have negative or positive values. The former score is an "under-fitting score, representing lower than expected quality elements for the Targeted product or the Upstream data while the latter is an "over-fitting" score. Both the under-fitting and over-fitting scores have been saturated at ±100% .

In order to associate a range of indicator values to an indicator score, it is necessary to

establish “thresholds”. It was decided that products with ‘errors’ within -10% and +10% with respect to DPS are ‘appropriate’ or at least partly adequate. Values smaller than -10% are under-fitting and not adequate while values large than +10% are over-fitting or totally adequate, no need for further development.

For a certain indicator value range, a color is associated with the following meaning:

- Red: the TDP or UD have errors between -100% and -10% and urgent actions are required to provide datasets fit for use by the Challenges – not adequate.
- Yellow: the TDP or UD have errors between -10% and +10% and can be considered quite appropriate and monitoring data are fit for use and should be maintained but also improved – partly adequate
- Green: the TDP or UD have errors between +10% and +100% and there is an ‘over – offer’, no need for further development –totally adequate

4. Analysis of the input data sets metadatabase

In the Black Sea Checkpoint metadatabase there are **503** data sets descriptions that are distributed among the eleven challenges, described by **42** P02 characteristic categories, **10** INSPIRE themes (over 34), **7** environmental matrices and **25** P03 group of characteristics. All the statistical information is provided in Annex 1. In the Table 4.1 a synthesis is displayed.

These data sets are potentially usable by the Challenge partners to generate their products. As we will see later, only **237** of these will be actually used by the Challenges.

The histogram of Fig. 4.2 illustrates the results of Table 4.1 making evident the larger number of P02, P03 and P22 categories potentially required by the first three Challenges with respect to the others.

Table 4.1 The number of input datasets by Challenge and the environmental matrices, P02, P03 and P22 characteristics by Challenge. (P02, P03, P22 numbers do not match with the overall "Numbers of different P02, P03 and P22 identified" because the same characteristic is requested by more than one Challenge).

	Challenge											
	Ch1 Windfarm siting	Ch2 Marine protected areas	Ch3 Oil platform leaks	Ch 4 Climate	Ch 5 Coasts	Ch6 Fishery management	Ch7 Fishery impacts	Ch8 Eutrophication	Ch 9 River inputs	Ch10 Bathymetry	Ch 11 Alien species	Unique input data sets
Number of input data sets identified	83	40	19	122	47	3	6	45	72	42	24	**503**
Environmental matrices identified	4	4	5	2	3	2	2	1	2	1	1	**7**
Numbers of different P03 identified	7	10	8	3	3	1	1	5	4	1	1	**25**
Numbers of different P02 identified	12	13	9	5	3	2	3	11	8	1	2	**42**
Numbers of different INSPIRE spatial themes identified (P22)	4	6	6	1	3	1	1	1	2	2	1	**10**

The histogram of Fig. 4.2 illustrates the results of Table 4.1 making evident the larger number of P02, P03 and P22 categories potentially required by the first three Challenges with respect to the others.

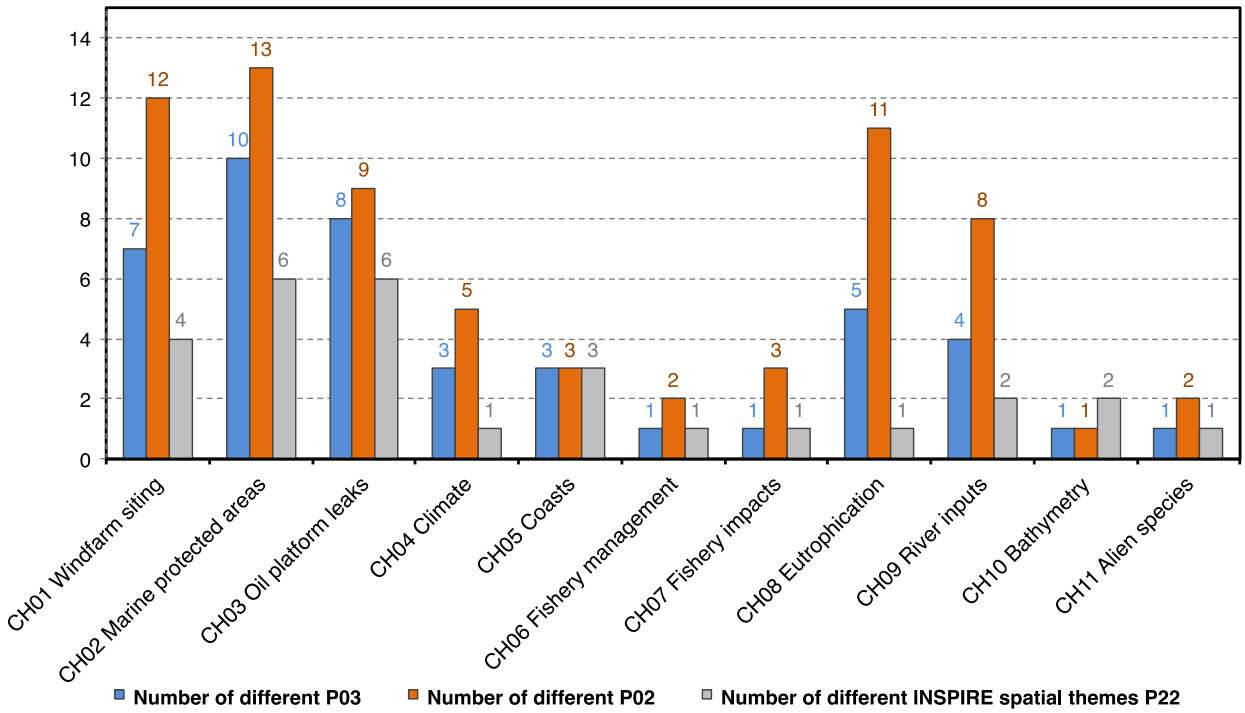


Figure 4.2: Number of characteristic categories identified by P02, P03 and P22 as a function of Challenges

The different number of input data sets potentially usable by the Challenges to generate their products is described in Figure 4.3 where it is evident that Windfarm siting, Climate, and River inputs request more data sets than the others.

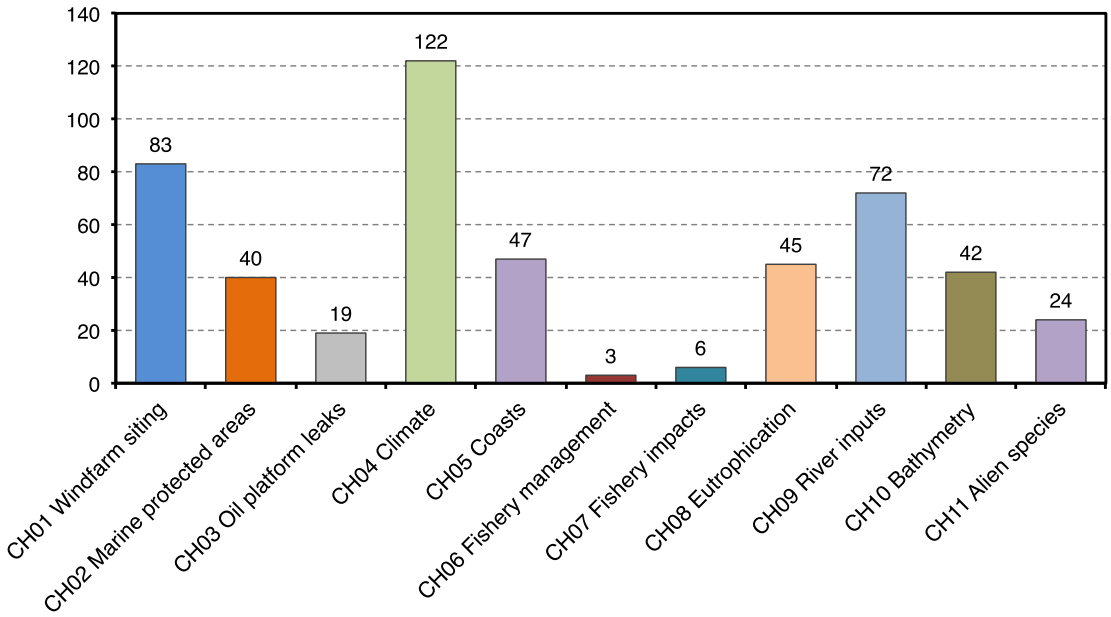


Figure 4.3 Number of input data sets for each Challenge

5. Analysis of the monitoring system by availability indicators

The availability indicators, described in Section 3, have been used here to carry out the first part of the monitoring system assessment . The indicators for the **503** input data sets, inserted in the metadatabase and potentially required by the Challenges, have been analysed by means of a distribution histograms of the scores.

5.1 Analysis of indicators across Challenges

In order to provide a visual indication of the input data availability, a colored table for each indicator has been produced as a function of Challenges. This assessment is done on the entire metadatabase constructed for all Challenges, and not only on the one referring only to the input data sets used for the products. The data sources selected for each Challenge and for each P02 characteristics could be more than one, and can have different availability indicators.

AV-VI-1: Easily Found

Table 5.1.1: Scores for the AV-VI-1 'Easily found' indicator as a function of Challenges for all input data sets. The last column indicates the score across all challenges

Indicator name	Meaningful (Symbol)	Achievable & Realistic (Choice)	CH 01	CH 02	CH 03	CH 04	CH 05	CH 06	CH 07	CH 08	CH 09	CH 10	CH 11	ALL
AV-VI-1	Low visibility	Choice 1: Red												
Easily found		*"Cited in peer reviewed paper or grey literature but*	8	0	4	8	0	0	0	1	0	0	0	21

		no info on how to access"												
		Choice 2 : Red												
		"Information retrieved upon specific request to the data source "	**23**	**9**	**3**	**19**	**3**	**0**	**0**	**0**	**1**	**0**	**0**	**58**
	Medium visibility	Choice 3: Yellow												
		"Use of social network, community of practices sharing information, portals of organization where no search is organized by an engine"	**0**	**4**	**0**	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**6**
	High visibility	Choice 4: Green												
		"Use of open search engines, searching by name either the data provider or the characteristics"	**5**	**21**	**5**	**94**	**6**	**3**	**6**	**29**	**51**	**1**	**24**	**245**
		Choice 5: Green												
		"Search via reference catalogue (e.g. Copernicus, GEOSS Geoportal…)"	**47**	**6**	**7**	**0**	**37**	**0**	**0**	**15**	**19**	**41**	**0**	**172**
		unknown	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**1**
		Total	**83**	**40**	**19**	**122**	**46**	**3**	**6**	**45**	**72**	**42**	**24**	**503**

For all Challenges more than the **83%** of the input data sets can be 'easily found', however Ch04 and Ch09 have most of the input data sets non 'easily found'.

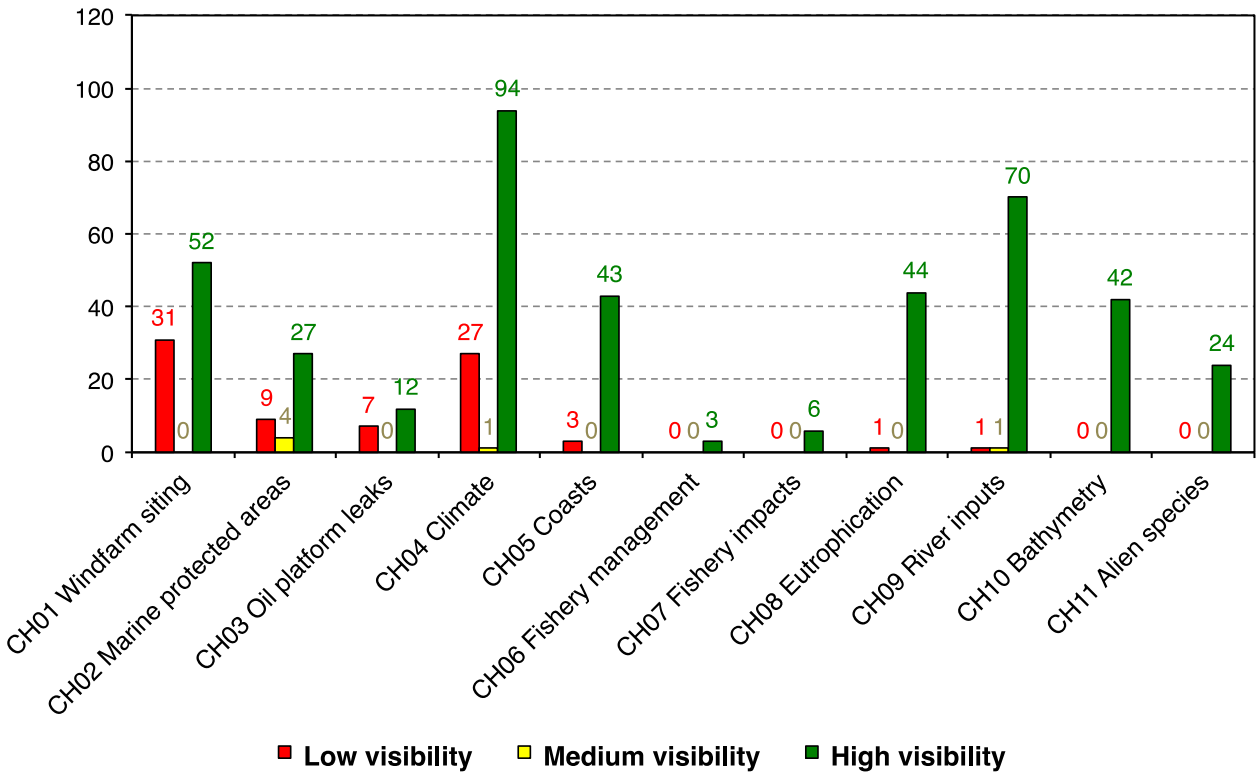


Figure 5.1.1: AV-VI-1 'Easily found' indicator across all Challenges

5.1.2 AV-VI-2: EU INSPIRE catalogue service

Table 5.1.2: Scores for the AV-VI-2 'EU INSPIRE catalogue service' indicator as a function of Challenges for all input data sets. The last column indicates the score across all challenges

Indicator name	Meaningful (Symbol)	Achievable & Realistic (Choice)	CH 01	CH 02	CH 03	CH 04	CH 05	CH 06	CH 07	CH 08	CH 09	CH 10	CH 11	ALL
AV-VI-2	Inadequate	Choice 1: Red												
Inspire catalogue service		*"Data sets are not referenced in a catalogue or are referenced in a non public catalogue"*	31	0	14	9	4	0	0	20	4	1	0	83
	Partially adequate	Choice 2: Yellow												
		"The datasets are referenced in a public national catalogue, in an international catalogue service "	52	40	5	113	43	3	6	25	68	41	24	420
	Totally adequate	Choice 3: Green												
		"Use of open search engines, searching by name either the data provider or the characteristics"	0	0	0	0	0	0	0	0	0	0	0	0
		unknown	0	0	0	0	0	0	0	0	0	0	0	0

	Total	83	40	19	122	47	3	6	45	72	42	24	503

There are no input data sets which are totally adequate to INSPIRE compliant catalogue services. Moreover, only around input 17% data sets are referenced in the public catalogues, national or international. All the rest is not referenced in any public catalogues. The worst cases are in Ch01 and Ch08.

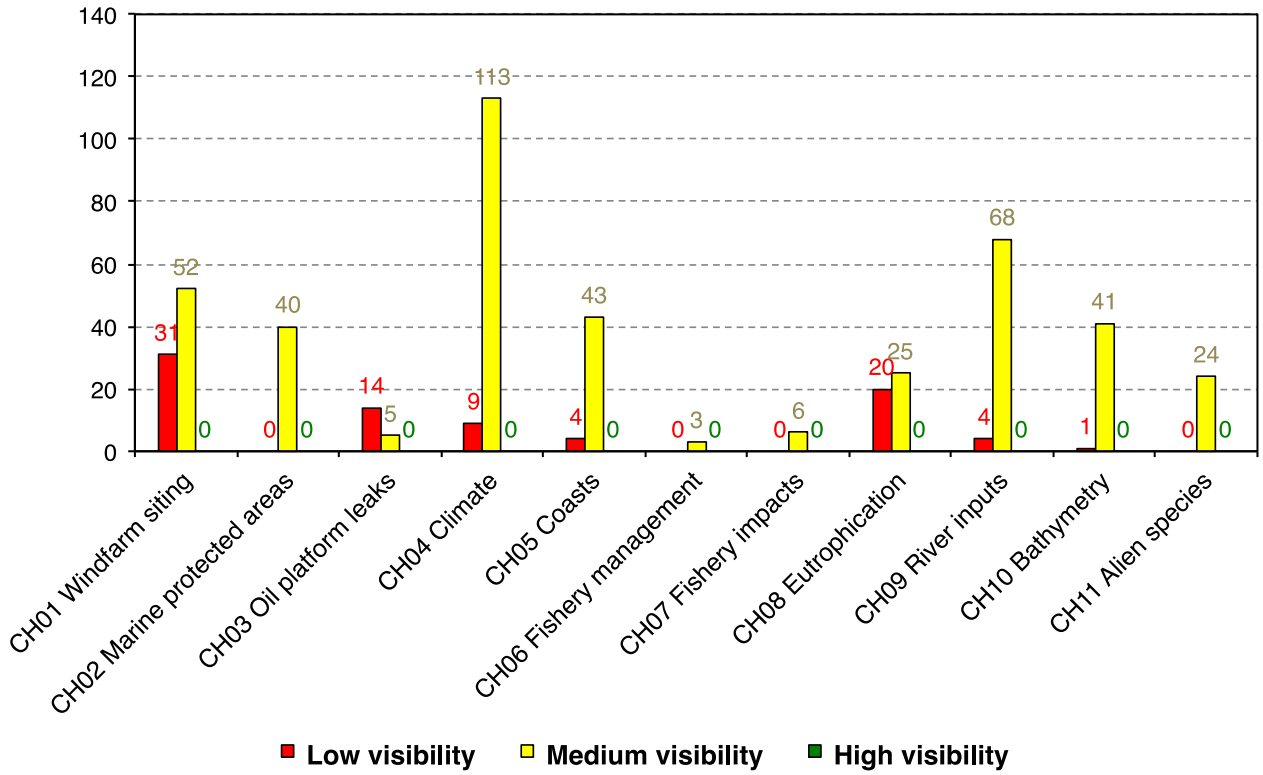


Figure 5.1.2: AV-VI-2 'EU INSPIRE catalogue service' indicator across all Challenges

5.1.3 AV-AC-1: Policy visibility

Table 5.3: Scores for the AV-AC-1 'Policy visibility' indicator as a function of Challenges for all input data sets. The last column indicates the score across all challenges

Indicator name	Meaningful (Symbol)	Achievable & Realistic (Choice)	CH 01	CH 02	CH 03	CH 04	CH 05	CH 06	CH 07	CH 08	CH 09	CH 10	CH 11	ALL
AV-AC-1	Low transparency	Choice 1: Red												
Policy visibility		*"There is no information at all on data policy adopted by data providers"*	8	0	0	27	2	0	0	19	19	0	4	79
	Medium transparency	Choice 2: Yellow												
		"There is information, but details are available only on request"	57	1	9	22	9	0	0	0	0	41	16	155
	High transparenc	Choice 3: Green												
		"There is detailed	18	39	10	73	36	3	6	26	53	1	4	269

	y	*information provided to understand data policy""*												
		unknown	0	0	0	0	0	0	0	0	0	0	0	0
		Total	**83**	**40**	**19**	**122**	**47**	**3**	**6**	**45**	**72**	**42**	**24**	**503**

For all Challenges there are more than 53% of input data sets with visible policy, red are about 16% and yellow about 31%. For this indicator the worst situation is in Challenge 3.

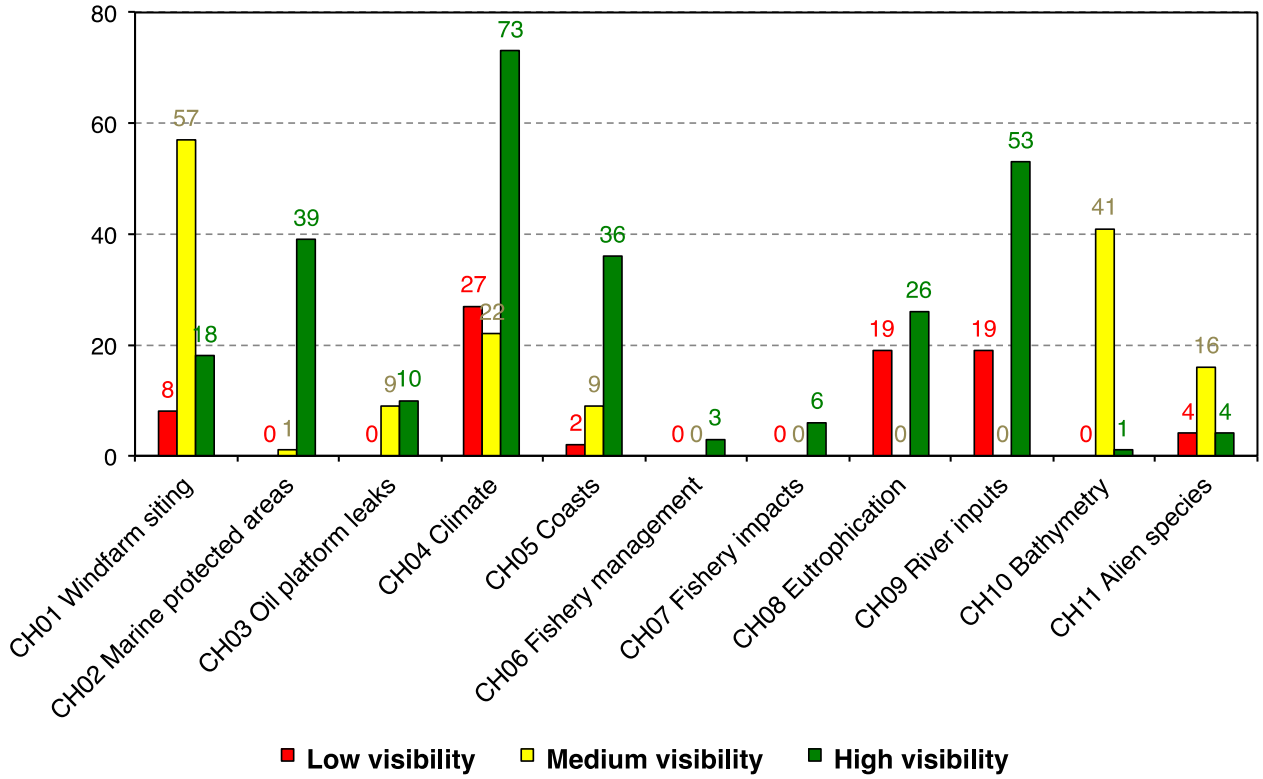


Figure 5.1.3: AV-AC-1 'Policy visibility' indicator across all Challenges

5.1.4 AV-AC-2: Delivery mechanism

Table 5.1.4: Scores for the AV-AC-2 'Delivery mechanism' indicator as a function of Challenges for all input data sets. The last column indicates the score across all challenges

Indicator name	Meaningful (Symbol)	Achievable & Realistic (Choice)	CH 01	CH 02	CH 03	CH 04	CH 05	CH 06	CH 07	CH 08	CH 09	CH 10	CH 11	ALL
AV-AC-2	No information or Manual	Choice 1: Red												
Delivery mechanism		*"No information was found on data delivery mechanisms"*	**8**	**0**	**0**	**25**	**1**	**0**	**0**	**0**	**0**	**0**	**16**	**50**
		Choice 2: Red												
		"Order form/invoice is requested"	**14**	**0**	**0**	**10**	**8**	**0**	**0**	**0**	**0**	**0**	**0**	**32**
	Partial	Choice 3: Yellow												

	Inspire function	*"Online downloading services"*	**1**	**22**	**11**	**5**	**3**	**0**	**0**	**0**	**2**	**1**	**2**	**47**
	Full Inspire function	Choice 4: Green												
		"Online discovery and downloading services"	**43**	**12**	**1**	**40**	**35**	**0**	**1**	**28**	**45**	**37**	**6**	**248**
		Choice 5: Green												
		"Online discovery + downloading + viewing services"	**11**	**6**	**7**	**32**	**0**	**3**	**5**	**16**	**25**	**0**	**0**	**105**
		unknown	**6**	**0**	**0**	**10**	**0**	**0**	**0**	**1**	**0**	**4**	**0**	**21**
		Total	**83**	**40**	**19**	**122**	**47**	**3**	**6**	**45**	**72**	**42**	**24**	**503**

For the delivery mechanism the green values are more than 70%, 16% of input data sets have a red indicator, and yellow is less then 10%.

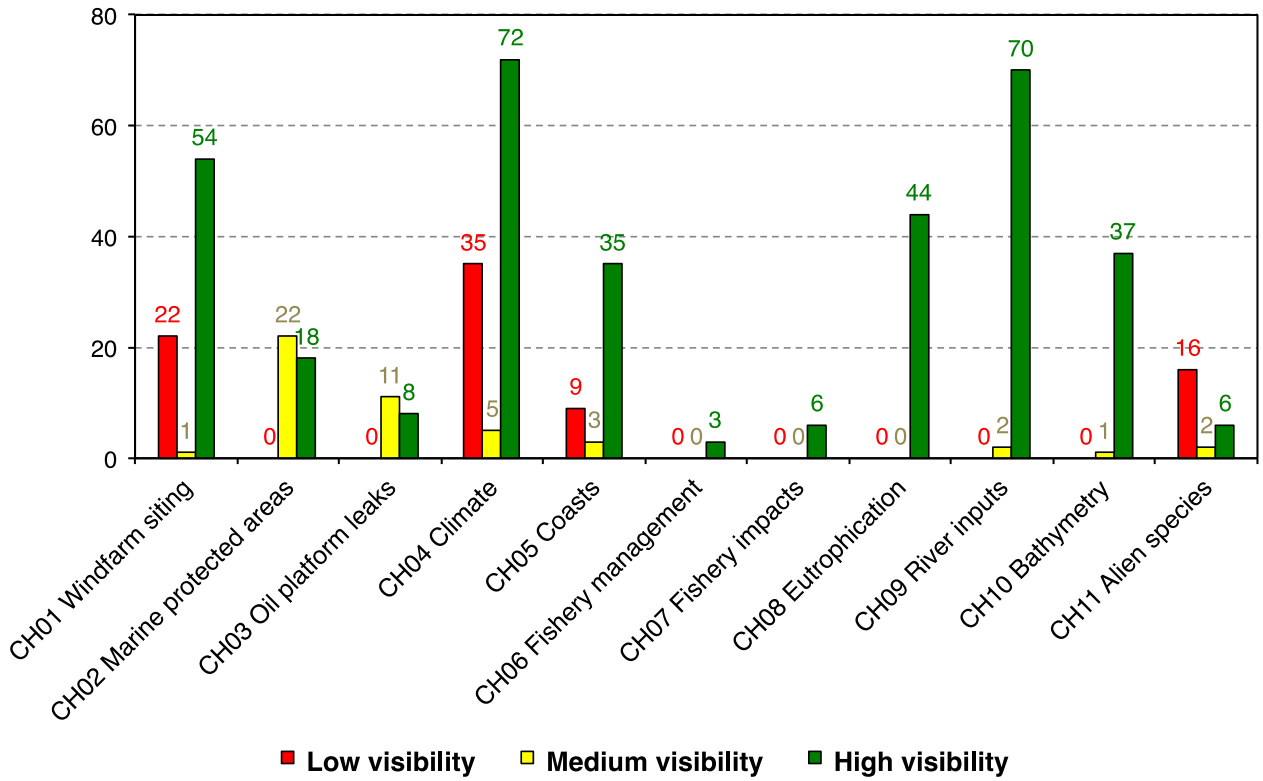


Figure 5.1.4: AV-AC-2 'Delivery mechanism' indicator across all Challenges

5.1.5 AV-AC-3: Data Policy

Table 5.1.5: Scores for the AV-AC-3 'Data Policy' indicator as a function of Challenges for all input data sets. The last column indicates the score across all challenges

Indicator name	Meaningful (Symbol)	Achievable & Realistic (Choice)	CH 01	CH 02	CH 03	CH 04	CH 05	CH 06	CH 07	CH 08	CH 09	CH 10	CH 11	ALL
AV-AC-3		Choice 1: Red												
Data policy	No documents	*"Not or not well documented"*	**41**	**0**	**0**	**11**	**2**	**0**	**0**	**0**	**0**	**41**	**0**	**95**

		Choice 2: Red											
		"Restricted"	**24**	**0**	**0**	**32**	**5**	**0**	**0**	**8**	**15**	**0**	**16**	**100**
	Partially restricted	Choice 3: Yellow											
		"Accessible under moratorium"	**1**	**19**	**11**	**17**	**4**	**0**	**0**	**2**	**2**	**0**	**4**	**60**
	Unrestricted	Choice 4: Green											
		"Unrestricted"	**17**	**21**	**8**	**62**	**36**	**3**	**6**	**34**	**55**	**1**	**4**	**247**
		unknown	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**1**
		Total	**83**	**40**	**19**	**122**	**47**	**3**	**6**	**45**	**72**	**42**	**24**	**503**

Data policy is still a problem. Only the 49% of input data sets are unrestricted, a 12% will be made open after the use by data collectors, and 19% are not documented.

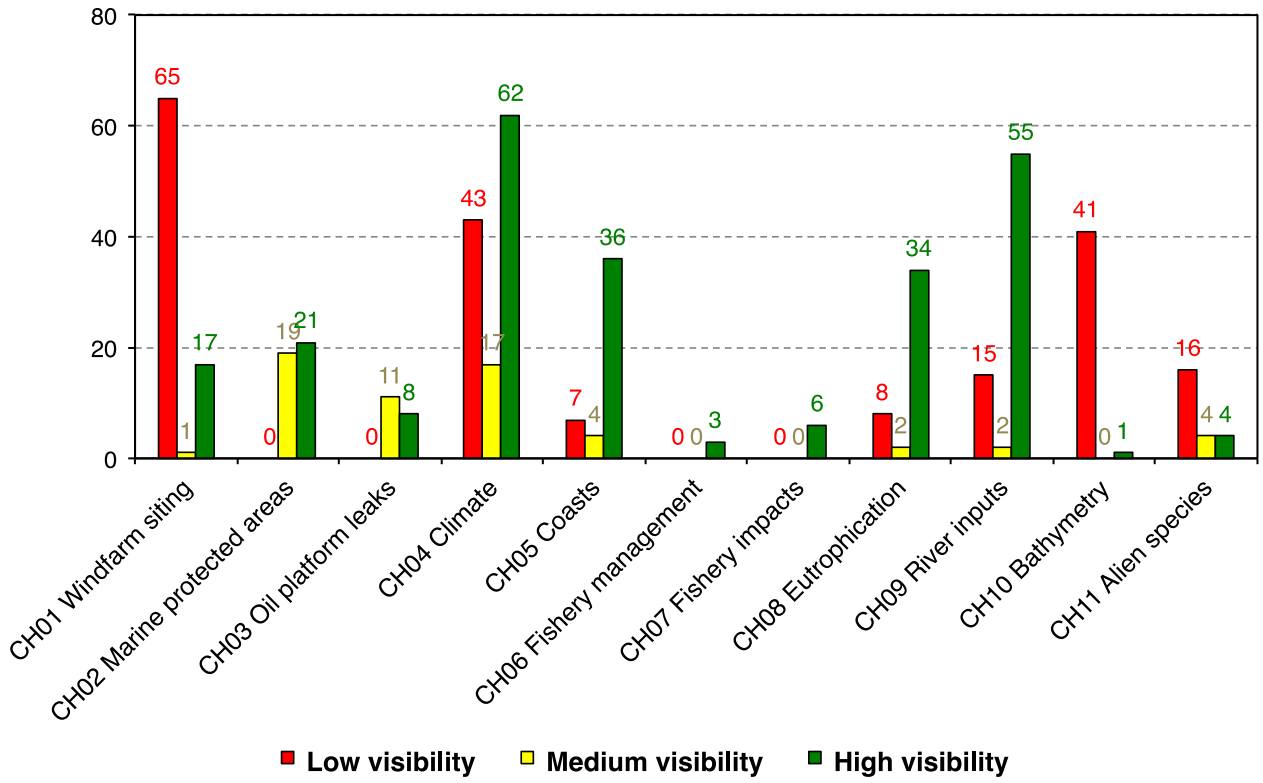


Figure 5.1.5: AV-AC-3 'Data Policy' indicator across all Challenges

5.1.6 AV-AC-4: Pricing

Table 5.1.6: Scores for the AV-AC-4 'Pricing' indicator as a function of Challenges for all input data sets. The last column indicates the score across all challenges

Indicator name	Meaningful (Symbol)	Achievable & Realistic (Choice)	CH 01	CH 02	CH 03	CH 04	CH 05	CH 06	CH 07	CH 08	CH 09	CH 10	CH 11	ALL
AV-AC-4	Not documented	Choice 1: Red												
Pricing		*"Not or not well documented"*	41	4	0	46	36	0	0	9	15	41	20	212
		Choice 2: Red												
		"Commercial cost charge"	1	0	0	0	3	0	0	0	0	1	0	5
	Cost Charge	Choice 3: Yellow												
		"Distribution charge"	16	0	0	1	0	0	0	0	0	0	2	19
		Choice 4: Yellow												
		"Collection charge" or "Free of charge for academic institutions and uses"	0	4	0	0	5	0	0	0	0	0	0	9
	Free	Choice 5: Green												
		"Open and Free, No charge"	25	32	19	75	3	3	6	35	57	0	2	257
		unknown	0	0	0	0	0	0	0	1	0	0	0	1
		Total	83	40	19	122	47	3	6	45	72	42	24	503

Pricing indicator is not good, since only 51% of input data sets are free. Reds in Ch05, Ch10, Ch11 must be noted.

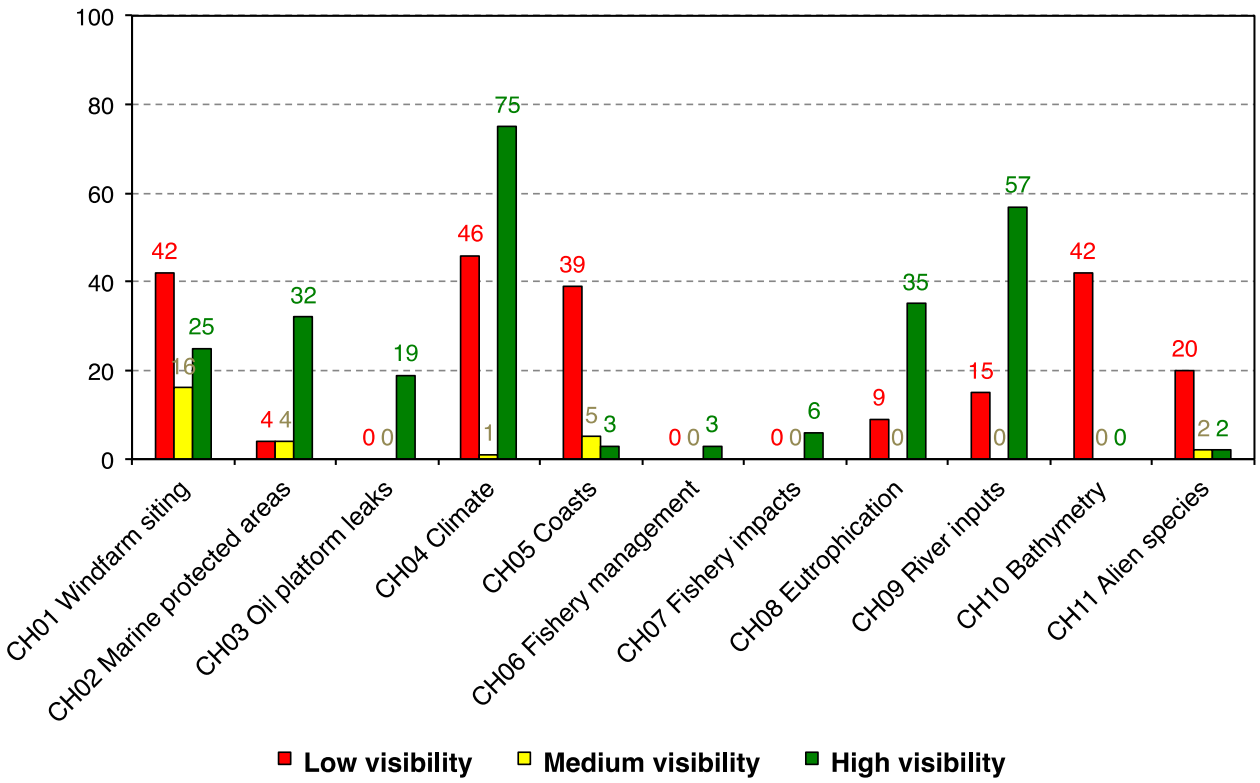


Figure 5.1.6: AV-AC-4 'Pricing' indicator across all Challenges

5.1.7 AV-AC-5: Readiness

Table 5.1.7: Scores for the AV-AC-5 'Readiness' indicator as a function of Challenges for all input data sets. The last column indicates the score across all challenges

Indicator name	Meaningful (Symbol)	Achievable & Realistic (Choice)	CH 01	CH 02	CH 03	CH 04	CH 05	CH 06	CH 07	CH 08	CH 09	CH 10	CH 11	ALL
AV-AC-5	No document	Choice 1: Red												
Readiness		*"Not or not well documented"*	8	0	0	51	3	0	0	0	0	0	0	62
	Not ready to be consumed	Choice 2: Red												
		"Proprietary and not well documented"	0	0	0	0	1	0	0	0	0	0	0	1
		Choice 3: Red												
		"Not proprietary but content not clearly specified"	0	0	0	13	0	0	0	0	1	0	12	26
	Can be processed to be consumed	Choice 4: Yellow												
		"Proprietary but content clearly specified"	41	4	0	1	8	3	2	0	0	41	2	102
	Ready to be consumed	**Choice 5: Green**												
		"Not proprietary and content clearly specified (eg auto-descriptive eg ODV, NetCDF CF) or at least with appropriate document describing the content"	33	35	19	55	35	0	4	44	71	0	10	306
		unknown	1	1	0	2	0	0	0	1	0	1	0	6
		Total	83	40	19	122	47	3	6	45	72	42	24	503

Also Readiness indicator is quite good for all Ch.s, since about 61% of input data sets are ready to be consumed. Reds in Ch04 and Ch11 must be noted.

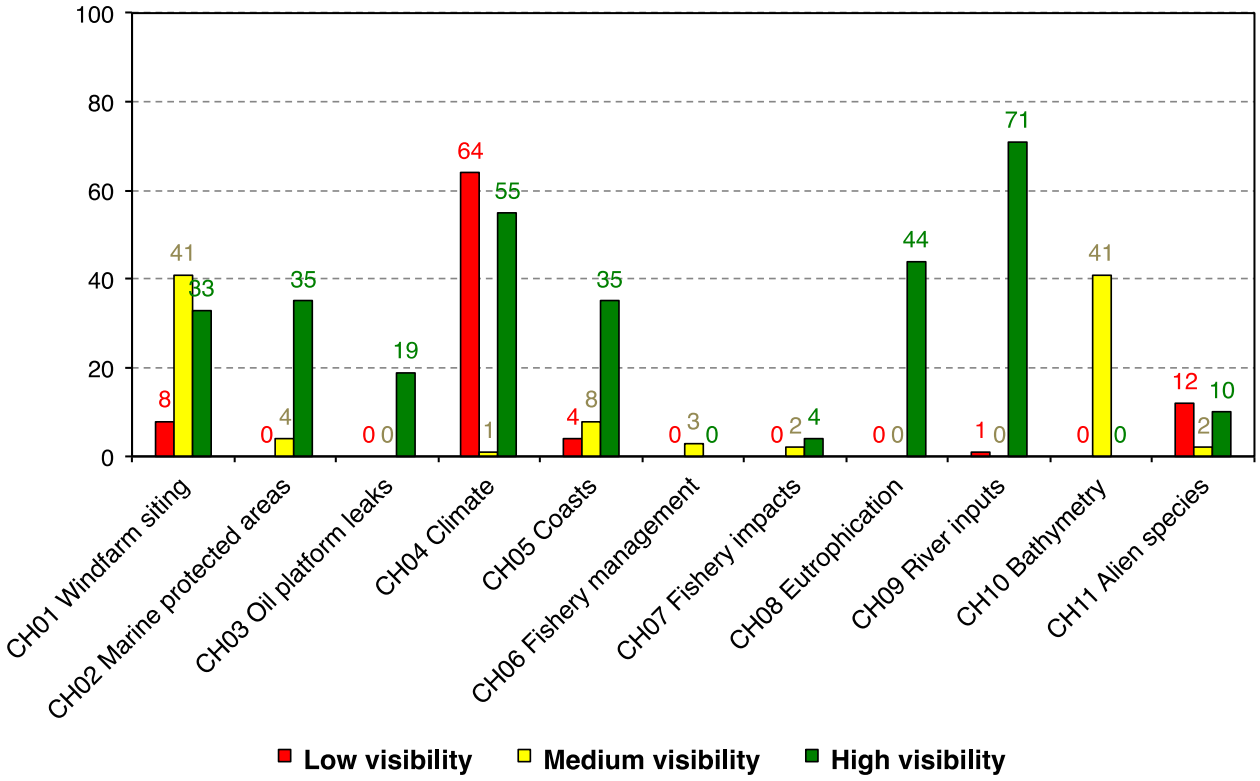


Figure 5.1.7: AV-AC-5 'Readiness' indicator across all Challenges

5.1.8 AV-PE-1: Responsiveness

Table 5.1.8: Scores for the AV-PE-1 'Responsiveness' indicator as a function of Challenges for all input data sets. The last column indicates the score across all challenges

Indicator name	Meaningful (Symbol)	Achievable & Realistic (Choice)	CH 01	CH 02	CH 03	CH 04	CH 05	CH 06	CH 07	CH 08	CH 09	CH 10	CH 11	ALL
AV-PE-1	Low response	Choice 1: Red												
Responsiveness		*"No information is found on response time"*	**49**	**1**	**0**	**49**	**8**	**0**	**0**	**28**	**15**	**41**	**20**	**211**
		Choice 2: Red												
		"More than 1 week for release"	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**1**
	Medium response	Choice 3: Yellow												
		"Less or equal to 1 week for release"	**16**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**2**	**20**
	High response	Choice 4: Green												
		"Online downloading (i.e. a few hours or less) for release"	**18**	**38**	**19**	**72**	**36**	**3**	**6**	**16**	**57**	**1**	**2**	**268**
		unknown	**0**	**1**	**0**	**1**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**3**
		Total	**83**	**40**	**19**	**122**	**47**	**3**	**6**	**45**	**72**	**42**	**24**	**503**

Responsiveness is presenting some problems. For all Challenges about the 53% of the input data sets are in high responsive systems, but red indicators are 42%, i.e., the same order of the green ones.

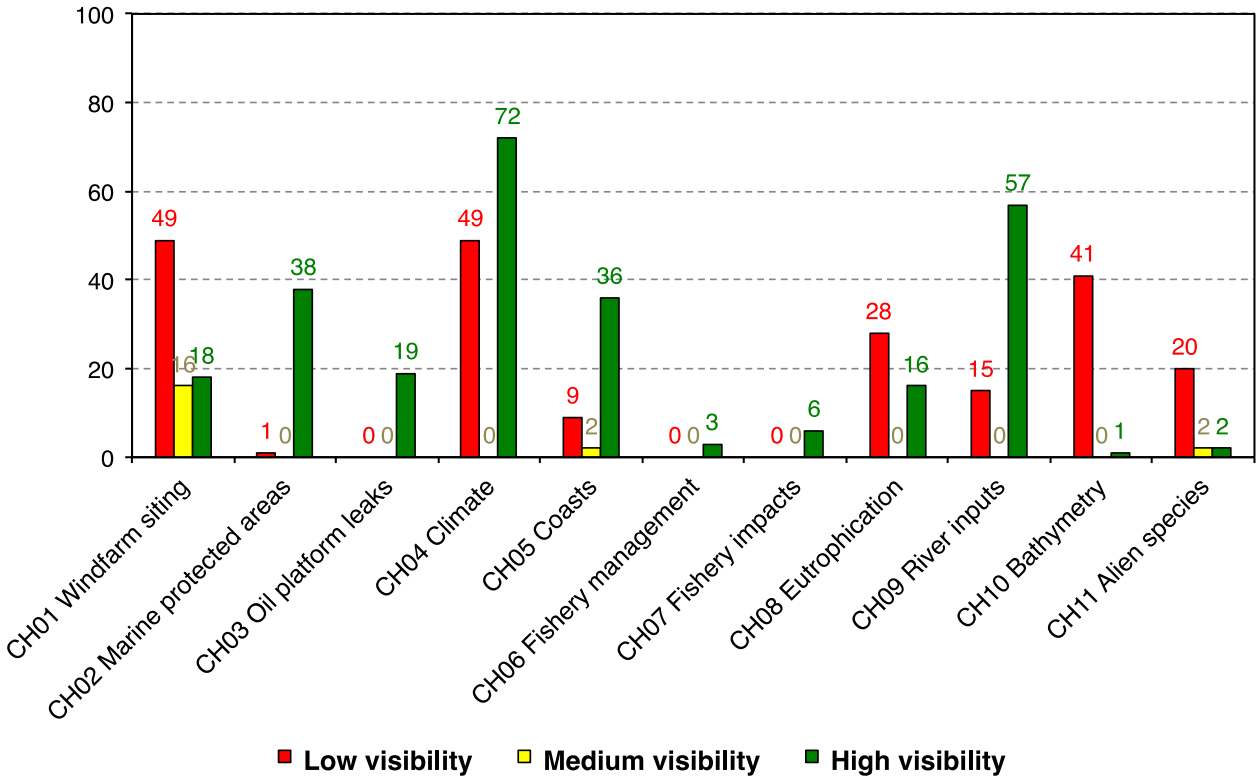


Figure 5.1.8: AV-PE-1 'Responsiveness' indicator across all Challenges

5.2 Analysis of adequacy of monitoring characteristics by availability

In order to assess the basin scale monitoring system on the basis of "availability" adequacy we need to organise the information across challenges, ordering the various indicators in terms of P02 characteristic categories. DGMARE decided to have a "theme" classification of the P02 characteristic categories, and we have grouped the P02 following this subdivision.

Table A3.2 lists the overall indicator scores as a function of P02 characteristic and for all the 503 data sets, across all the challenges that use the same P02. Table A3.2 is reproduced in Table 5.2.1. The colour inserted is the one representing the largest number of data sets color or score, i.e. the most frequent colour in Table A3.1. If two colour scores had the same number of occurrences, the "best score" was reported as "overall score" for the specific P02 and availability indicator.

Table 5.2.1 Overall availability scores by P02 Characteristics. The overall score represents the most frequent colour among the different scores given by the different Challenges and the different data sets.

P02 characteristics category	# of data sets	Easily found	INSPIRE catalog service	Visibility of data policy	Data delivery	Data policy	Pricing	Readiness	Responsiveness
Bathymetry									
1.Bathymetry and Elevation	88								
2. Terrestrial mapping	1								
Geology									
3. Coastal geomorphology	3								
4. Concentration of suspended particulate material in the water column	8								
5. Geological sample density	1								
Physics									
6. Horizontal velocity of the water column (currents)	9								
7. River flow and discharge	16								
8. Salinity of the water column	2								
9. Sea level	54								
10. Spectral wave data parameters	2								
11. Temperature of the water column	127								
12. Skin temperature of the water column	11								
13. Wave direction	1								
14. Wave height and period statistics	8								
15. Wind strength and direction	8								
Chemistry									
16. Dissolved oxygen parameters in the water column	2								

P02 characteristics category	# of data sets	Easily found	INSPIRE catalog service	Visibility of data policy	Data delivery	Data policy	Pricing	Readiness	Responsiveness
17. Dissolved total and organic nitrogen concentrations in the water column	6								
18. Dissolved total or organic phosphorus concentration in the water column	2								
19. Nitrate concentration parameters in the water column	29								
20. Particulate total and organic phosphorus concentrations in the water column	5								
21. Phosphate concentration parameters in the water column	21								
Biology									
22. Bird taxonomy-related counts	4								
23. Cetacean abundance	2								
24. Chlorophyll pigment concentrations in the water column	5								
25. Chlorophyll pigment concentrations in water bodies	4								
26. Fauna abundance per unit area of the bed	5								
27. Fish biomass in water bodies	1								
28. Fish taxonomy-related counts	2								
Habitats									
29. Habitat extent	3								
30. Phytoplankton generic abundance in water bodies	5								
31. Phytoplankton generic biomass in water bodies	6								
32. Phytoplankton taxonomic surface area in water bodies	1								
33. Zooplankton taxonomy-related abundance per unit volume of the water column	13								
34. Zooplankton wet weight biomass	11								
Human activity									
35. Fish and shellfish catch statistics	4								
36. Fishery characterisation	3								
37. Administrative units	4								
Others									
38. Air pressure	1								
39. Air temperature	2								
40. Atmospheric humidity	2								
41. Other physical and chemical properties of suspended particulate material	4								
42. Snow and ice mass, thickness and extent	17								

P02 characteristics category	# of data sets	Easily found	INSPIRE catalog service	Visibility of data policy	Data delivery	Data policy	Pricing	Readiness	Responsiveness
P02 in TOTAL: 42	**Data sets in TOTAL 503**								

Sub-diving the 42 P02 characteristic categories into “themes” we can say that:

- ***Bathymetry***: bathymetry and elevation data are inadequate in terms of Data policy, Pricing, and Responsiveness.
- ***Geology***: coastal geomorphology data are totally inadequate in terms of Data delivery; geological sample density is inadequate for Easily found and INSPIRE Catalogue.
- ***Physics***: many characteristics are totally inadequate for Easily found, INSPIRE Catalogue, and Data delivery. However, water temperature data have good availability scores.
- ***Chemistry***: the main problems are found for Visibility of data policy and Responsiveness; INSPIRE Catalogue service is not good enough everywhere
- ***Biology***: Data delivery and Data policy are not good enough. The birds taxonomy is not Easily Found; chlorophyll pigment concentration has inadequate Responsiveness.
- ***Habitats***: all plankton characteristics are inadequate for many availability indicators: Visibility of data policy, Data delivery, Priciong, readiness and Responsiveness. Habitat extent is not Easily found.
- ***Human activity***: INSPIRE catalogue service is not good.
- ***Others***: atmospheric conditions in general are totally and partly inadequate.

These 42 characteristic categories have been ordered in terms of inadequacy in Table 5.2.2.

Table 5.2.2 P02 characteristic categories that are inadequate for availability indicators in order of inadequacy

P02 characteristics	# of Red scores	# of Yellow scores	# of Green scores	number of data sets
1. Air pressure	5	1	2	1
2. Zooplankton taxonomy-related abundance per unit volume of the water column	4	3	1	13
3. Zooplankton wet weight biomass	4	3	1	11
4. Phytoplankton generic biomass in water bodies	4	2	2	6
5. Phytoplankton generic abundance in water bodies	4	1	3	5
6. Wave height and period statistics	3	4	1	8
7. Spectral wave data parameters	3	4	1	2
8. Bathymetry and Elevation	3	3	2	88
9. Salinity of the water column	3	3	2	2
10. Atmospheric humidity	3	3	2	2
11. Air temperature	2	3	3	2
12. Geological sample density	2	3	3	1
13. Wind strength and direction	2	2	4	8
14. Horizontal velocity of the water column (currents)	2	1	5	9
15. Dissolved total or organic phosphorus concentration in the water column	2	1	5	2
16. Dissolved oxygen parameters in the water column	2	1	5	2
17. Wave direction	2	0	6	1
18. Habitat extent	1	4	3	3
19. Bird taxonomy-related counts	1	3	4	4
20. Sea level	1	1	6	54
21. Phosphate concentration parameters in the water column	1	1	6	21
22. Particulate total and organic phosphorus concentrations in the water column	1	1	6	5
23. Chlorophyll pigment concentrations in water bodies	1	1	6	4
24. Coastal geomorphology	1	1	6	3
25. Phytoplankton taxonomic surface area in water bodies	1	1	6	1
26. River flow	0	2	6	16

P02 characteristics	# of Red scores	# of Yellow scores	# of Green scores	number of data sets
27. Skin temperature of the water column	0	2	6	11
28. Fauna abundance per unit area of the bed	0	2	6	5
29. Chlorophyll pigment concentrations in the water column	0	2	6	5
30. Administrative units	0	2	6	4
31. Fish taxonomy-related counts	0	2	6	2
32. Cetacean abundance	0	2	6	2
33. Terrestrial mapping	0	2	6	1
34. Temperature of the water column	0	1	7	127
35. Nitrate concentration parameters in the water column	0	1	7	29
36. Snow and ice mass, thickness and extent	0	1	7	17
37. Concentration of suspended particulate material in the water column	0	1	7	8
38. Dissolved total and organic nitrogen concentrations in the water column	0	1	7	6
39. Other physical and chemical properties of suspended particulate material	0	1	7	4
40. Fish and shellfish catch statistics	0	1	7	4
41. Fishery characterisation	0	1	7	3
42. Fish biomass in water bodies	0	1	7	1
Total	58	76	202	503

Table 5.2.2 is presented graphically below as Figure 5.2.2.

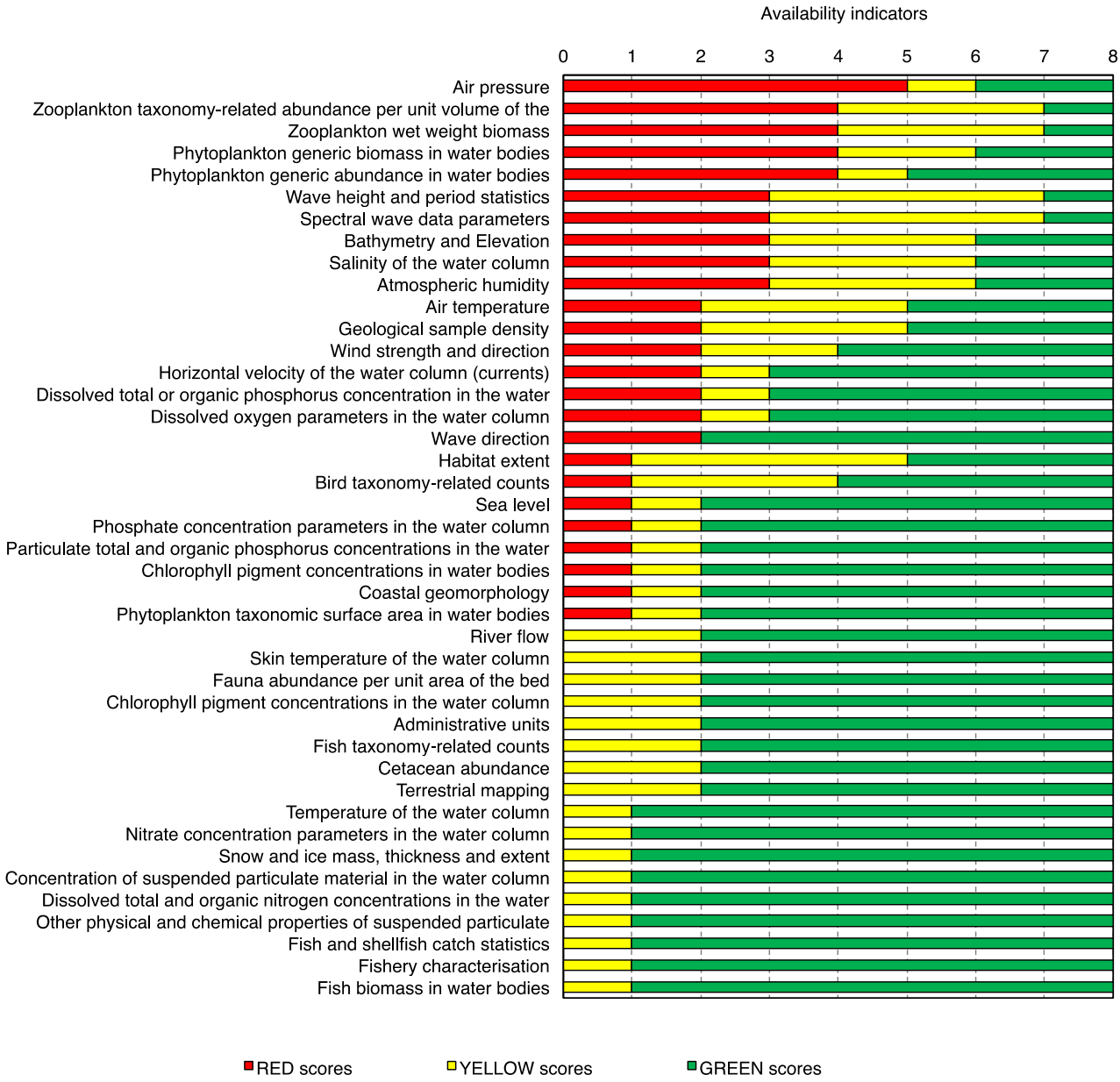
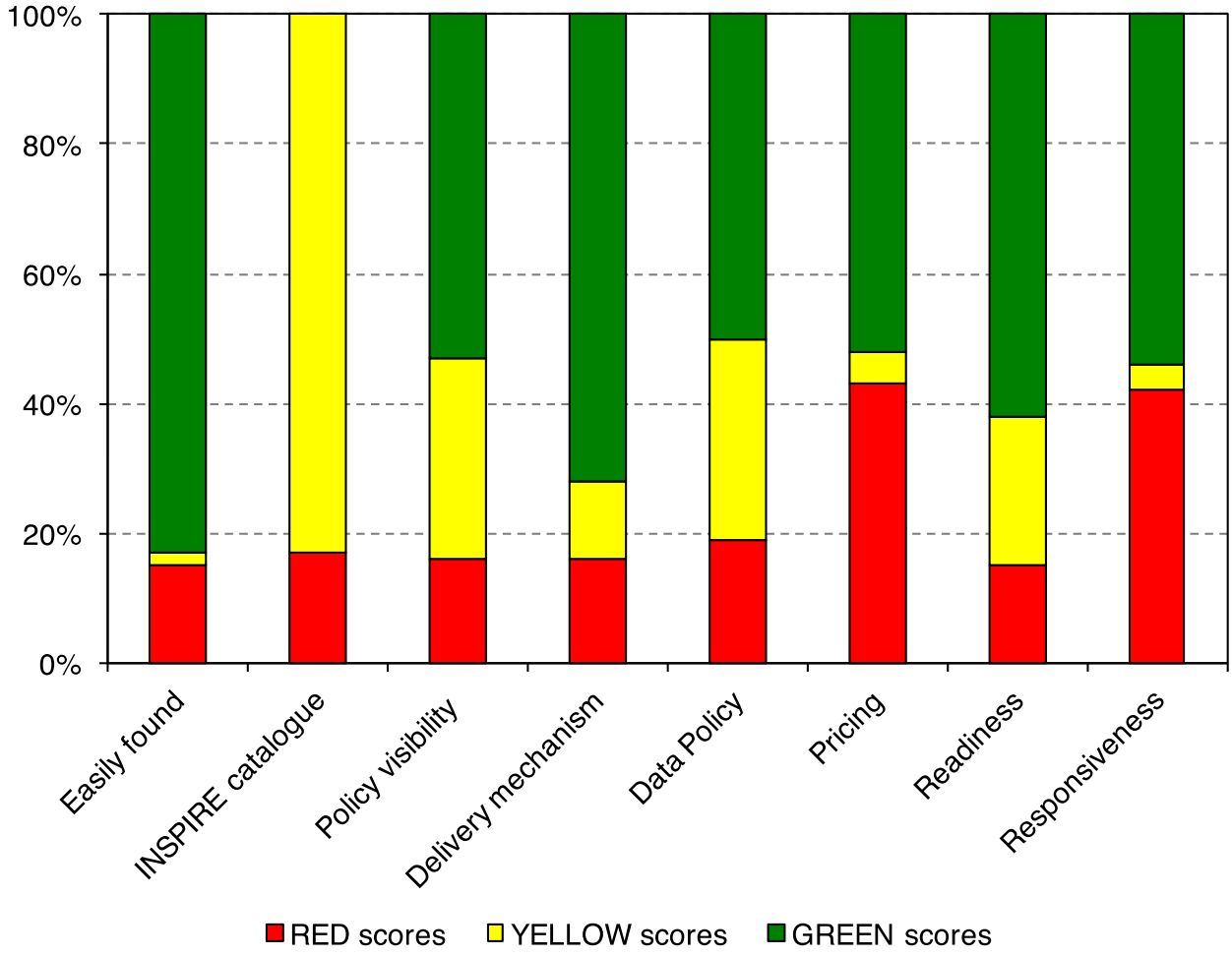


Figure 5.2.2 P02 characteristic categories and their score for the 8 availability indicators

The conclusion is that 17 basin scale characteristic categories are not adequately monitored in the Black Sea if we consider at least 2 red scores across the availability indicators as the threshold to define the inadequacy.

These results are also summarized in Table 5.2.3 where the availability indicator scores are now summed considering all the input data sets without distinguishing the P02 characteristics. This analysis shows that ALL input data sets contributing to the monitoring of the Black Sea are totally and partly inadequate of the data set in terms of the INSPIRE Catalogue. Moreover above 40% of the input data sets contributing to the monitoring of the Black Sea are partly and totally inadequate for Policy visibility, Data Policy, Pricing, and Responsiveness.

Table 5.2.3 Availability indicators scores in percentage over the total number of input data sets (503) present in the metadatabase.



5.3 Analysis of availability indicators for Copernicus and EMODnet services

A special analysis has been carried out specifically for the Copernicus and EMODnet Portals data sets. This is reported in Table 5.3.1.

Results indicate that CMEMS provided weak Data policy and INSPIRE catalog service especially for currents and water temperature; sea level data have bad Pricing. This unexpected situation was typical of the past. Since November 2016, CMEMS has provided these data on a regural basis, which improves the situation drastically.

EMODnet Portals instead have:

- not completely structured in a user-friendly EU-INSPIRE web portals;
- high inadequacy is found in Pricing, Readiness, and Responsiveness;

Table 5.3.1 Copernicus and EMODnet Portals availability indicator scores

Data set provider: Copernicus Marine environment monitoring service

P02 characteristics	Easily found			INSPIRE catalogue			Visibility of Data policy			Data delivery			Data policy			Pricing			Readiness			Responsiveness		
1. Chlorophyll pigment concentrations in water bodies		1			1				1			1		1				1			1			1
2. Chlorophyll pigment concentrations in water column		1			1				1			1		1				1			1			1
3. Horizontal velocity of the water column (currents)	1		1	1	1			1	1			2		1	1			2			2			2
4. Phytoplankton generic abundance in water bodies		1			1				1			1		1				1			1			1
5. Skin temperature of the water column			10		10				10			10		10				10			10			10
6. Temperature of the water column	1		28	1	28			1	28			29	1	4	24			29			29	5		24
7. Sea level			16	1	15				16			16			16	16					16			16

Data set provider: EMODnet

P02 characteristics	Easily found			INSPIRE catalogue			Visibility of Data policy			Data delivery			Data policy			Pricing			Readiness			Responsiveness		
1. Bathymetry and Elevation	1				1				1		1			1				1		1				1
2. Coastal geomorphology			1		1				1			1			1			1			1			1
3. Concentration of suspended particulate material in the water column			1		1				1			1		1		1			1			1		
4. Dissolved total and organic nitrogen concentrations in the water column			2		2				2			2		2		2			2			2		
5. Nitrate concentration parameters in the water column			13		13				13			13		5	8	5		8			13	7		6
6. Particulate total and organic phosphorus concentrations in the water column			1		1				1			1		1		1					1	1		

P02 characteristics	Easily found			INSPIRE catalogue			Visibility of Data policy			Data delivery			Data policy			Pricing			Readiness			Responsiveness		
7. Phosphate concentration parameters in the water column			14	7	7		2		12			14		6	8	6		8			14	10		4

6. Analysis of monitoring system by appropriateness indicators

The appropriateness indicators, described in Section 3 and Annex 2, have been used to define the adequacy of the monitoring system for the different quality elements that compose the appropriateness territory. Here we discuss the results of the statistical analysis of the indicators for all the input data sets used in the Challenge products.

6.1 Analysis of appropriateness indicators across products

Using the Appropriateness indicators defined in Annex 2 for the Upstream Data we can extract the characteristics that have negative appropriateness indicator values, i.e. they do not comply with the specifications given for the targeted product.

As written in section 3, the scores are as follows:
Red: the Upstream Data (UD) have errors between -100% and -10% and urgent actions are required to provide datasets fit for use by the Challenges – not adequate
Yellow: the UD have errors between -10% and +10% and can be considered quite appropriate and monitoring data are fit for use and should be maintained but also improved – partly adequate
Green: the UD have errors between +10% and +100% and there is an 'over – offer', no need for further development –totally adequate

Only 253 of the potential 503 data sets, which cover only 27 of the P02 characteristic categories, are used in the Challenge products. Table 6.1 shows the scores across all Challenge products and their upstream data.

Table 6.1 Upstream data sets appropriateness indicators as a function of P02 across all Challenges. Numbers on the color scores indicate the number of Upstream Data that have that score thus giving an indication of the prevailing value.

List of P02 Characteristics related to input data sets	Horizontal Coverage UD.APE.1.1	Vertical Coverage UD.APE.1.2	Temporal Coverage UD.APE.1.3	Horizontal Resolution UD.APE.3.1	Vertical Resolution UD.APE.3.2	Temporal Resolution UD.APE.3.3	Thematic Accuracy UD.APE.3.4	Temporal Validity UD.APE.4.1
1. Administrative units	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2
2. Bathymetry and elevation	6 4	2 6 2	4 6	2 4 4	8 2	4 4 2 N/A	6 4 N/A	2 6 2
3. Bird taxonomy-related counts	1	1	1	1	1	1	1	1
4. Cetacean abundance	1	1	1	1	1	1	1	1

List of P02 Characteristics related to input data sets	Horizontal Coverage UD.APE.1.1	Vertical Coverage UD.APE.1.2	Temporal Coverage UD.APE.1.3	Horizontal Resolution UD.APE.3.1	Vertical Resolution UD.APE.3.2	Temporal Resolution UD.APE.3.3	Thematic Accuracy UD.APE.3.4	Temporal Validity UD.APE.4.1
5. Chlorophyll pigment concentrations in the water column	3 N/A	3 N/A	3 N/A	3 N/A	3 N/A	3 N/A	3 N/A	3 N/A
6. Chlorophyll pigment concentrations in water bodies	1 5 N/A	1 5 N/A	1 5 N/A	1 5 N/A	6 N/A	1 5 N/A	1 5 N/A	1 5 N/A
7. Coastal geomorphology	1 6 N/A	1 6 N/A	1 6 N/A	1 6 N/A	7 N/A	1 6 N/A	7 N/A	1 6 N/A
8. Dissolved total and organic nitrogen concentrations in the water column	1 1 N/A	2 N/A	1 1 N/A	1 1 N/A	1 1 N/A	1 1 N/A	1 1 N/A	1 1 N/A
9. Fauna abundance per unit area of the bed	1	1	1	1	1	1	1	1
10. Fish and shellfish catch statistics	7	7	7	7	7	6 1	7	7
11. Fishery characterisation	8	8	8	8	8	8	8	8
12. Geological sample density	2 N/A	2 N/A	2 N/A	2 N/A	2 N/A	2 N/A	2	2
13. Habitat extent	9	8 1	9	9	9	9	8 1 N/A	9
14. Horizontal velocity of the water column (currents)	8	4 4 N/A	4 4	8	4 4 N/A	8	4 4N/A	8
15. Nitrate concentration parameters in the water column	20 2 2 N/A	24 N/A	23 1 N/A	23 1 N/A	11 12 1N/A	23 1 N/A	23 1 N/A	23 1 N/A
16. Phosphate concentration parameters in the water column	1 13 1	15 N/A	15	15	2 13	15	15	15
17. Phytoplankton generic abundance in water bodies	2	2	1 0 1 N/A	2 N/A	2 N/A	2	2	2
18. River flow and discharge	29	29 N/A	29	29	27 2 N/A	27 2 N/A	29	29
19. Sea level	1 1 24 N/A	26 N/A	4 1 14 7 N/A	1 1 24 N/A	26 N/A	26 N/A	20 6 N/A	10 10 6 N/A

List of P02 Characteristics related to input data sets	Horizontal Coverage UD.APE.1.1	Vertical Coverage UD.APE.1.2	Temporal Coverage UD.APE.1.3	Horizontal Resolution UD.APE.3.1	Vertical Resolution UD.APE.3.2	Temporal Resolution UD.APE.3.3	Thematic Accuracy UD.APE.3.4	Temporal Validity UD.APE.4.1
20. Skin temperature of the water column	2 11 N/A	13 N/A	1 2 10 N/A	3 10 N/A	13 N/A	13 N/A	3 10 N/A	3 10 N/A
21. Snow and ice mass, thickness and extent	2	2 N/A	1 1	2	2 N/A	2	2	2
22. Temperature of the water column	1 3 2 N/A	2 13 N/A	1 3 2 N/A	1 3 2 N/A	9 4 2 N/A	1 3 2 N/A	1 1 4 N/A	1 3 2 N/A
23. Terrestrial mapping	1	1	1	1	1	1	1 N/A	1
24. Wave height and period statistics	6	6	6	6	6	6	6	6
25. Wind strength and direction	3	3	3	3	3	3	3	3
26. Zooplankton taxonomy-related abundance per unit volume of the water column	7	4 3	7	3 3 1 N/A	3 4	7	7	7
27. Zooplankton wet weight biomass	7	4 3	7	2 4 1 N/A	3 4	7	7	7

We first note that some characteristic categories in Table 6.1 use only less than 5 upstream data sets for the analysis and this makes the results uncertain from a statistical point of view. The most frequent quality elements that score “not adequate” are:

- horizontal coverage;
- vertical coverage;
- temporal validity.

Less problems are found for:

- temporal coverage;
- horizontal resolution.

Table 6.2 below presents only overall indicator values for appropriateness. We apply now the same filter as for the availability indicators, but we select only the characteristic categories that have at least one “overall” red score or 5 yellow scores among the appropriateness indicators. The “overall score” is defined as the score with largest number of occurrences for the specific P02 and indicator. The results of this analysis are shown in Table 6.2 and Table 6.3.

Table 6.2 Upstream data sets overall indicator values for appropriateness as a function of P02 across all Challenges and data sets.

List of P02 Characteristics related to input data sets	Horizontal Coverage UD.APE.1.1	Vertical Coverage UD.APE.1.2	Temporal Coverage UD.APE.1.3	Horizontal Resolution UD.APE.3.1	Vertical Resolution UD.APE.3.2	Temporal Resolution UD.APE.3.3	Thematic Accuracy UD.APE.3.4	Temporal Validity UD.APE.4.1
1. Administrative units								
2. Bathymetry and elevation								
3. Bird taxonomy-related counts								
4. Cetacean abundance								
5. Chlorophyll pigment concentrations in the water column								
6. Chlorophyll pigment concentrations in water bodies								
7. Coastal geomorphology								
8. Dissolved total and organic nitrogen concentrations in the water column								
9. Fauna abundance per unit area of the bed								
10. Fish and shellfish catch statistics								
11. Fishery characterisation								
12. Geological sample density								
13. Habitat extent								
14. Horizontal velocity of the water column (currents)								
15. Nitrate concentration parameters in the water column								
16. Phosphate concentration parameters in the water column								
17. Phytoplankton generic abundance in water bodies								
18. River flow and discharge								
19. Sea level								
20. Skin temperature of the water column								
21. Snow and ice mass, thickness and extent								

List of P02 Characteristics related to input data sets	Horizontal Coverage UD.APE.1.1	Vertical Coverage UD.APE.1.2	Temporal Coverage UD.APE.1.3	Horizontal Resolution UD.APE.3.1	Vertical Resolution UD.APE.3.2	Temporal Resolution UD.APE.3.3	Thematic Accuracy UD.APE.3.4	Temporal Validity UD.APE.4.1
22. Temperature of the water column								
23. Terrestrial mapping								
24. Wave height and period statistics								
25. Wind strength and direction								
26. Zooplankton taxonomy-related abundance per unit volume of the water column								
27. Zooplankton wet weight biomass								

Table 6.3 Upstream data sets appropriateness indicators as a function of P02 across all Challenges only for P02 that have at least one "overall" red score or 5 yellow scores in Table 6.2.

List of P02 Characteristics related to input data sets	Horizontal Coverage UD.APE.1.1	Vertical Coverage UD.APE.1.2	Temporal Coverage UD.APE.1.3	Horizontal Resolution UD.APE.3.1	Vertical Resolution UD.APE.3.2	Temporal Resolution UD.APE.3.3	Thematic Accuracy UD.APE.3.4	Temporal Validity UD.APE.4.1
1. Zooplankton taxonomy-related abundance per unit volume of the water column	7	4 3	7	3 3 1 N/A	3 4 10 NA	7 11 NA	7	7
2. Zooplankton wet weight biomass	7	4 3	7	2 4 1 N/A	3 4	7	7	7
3. Phytoplankton generic abundance in water bodies	2	2	1 1 N/A	2 N/A	2 N/A	2	2	2
4. Temperature of the water column	1 3 2 N/A	2 13 N/A	1 3 2 N/A	1 3 2 N/A	9 4 2 N/A	1 3 2 N/A	1 1 4 N/A	1 3 2 N/A
5. Skin temperature of the water column	2 1 1 N/A	13 N/A	1 2 10 N/A	3 10 N/A	13 N/A	13 N/A	3 10 N/A	3 10 N/A
6. Bathymetry and elevation	6 4	2 6 4	4 6	2 4 4	8 2	4 4 2 N/A	6 4 N/A	2 6 2
7. Terrestrial mapping	1	1	1	1	1	1	1 N/A	1
8. Administrative units	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2
9. Habitat extent	9	8 1	9	9	9	9	8 1 N/A	9
10. Fishery characterisation	8	8	8	8	8	8	8	8
11. Fish and shellfish catch statistics	7	7	7	7	7	6 1	7	7
12. Wave height and period statistics	6	6	6	6	6	6	6	6

List of P02 Characteristics related to input data sets	Horizontal Coverage UD.APE.1.1	Vertical Coverage UD.APE.1.2	Temporal Coverage UD.APE.1.3	Horizontal Resolution UD.APE.3.1	Vertical Resolution UD.APE.3.2	Temporal Resolution UD.APE.3.3	Thematic Accuracy UD.APE.3.4	Temporal Validity UD.APE.4.1
13. Wind strength and direction	3	3	3	3	3	3	3	3
14. Bird taxonomy-related counts	1	1	1	1	1	1	1	1
15. Cetacean abundance	1	1	1	1	1	1	1	1
16. Fauna abundance per unit area of the bed	1	1	1	1	1	1	1	1
17. Coastal geomorphology	1	1	1	1	7 N/A	6 N/A	7 N/A	1
18. River flow and discharge	29	29 N/A	29	29	27	27	29	29
19. Nitrate concentration parameters in the water column	20	24 N/A	23	23	11	23	23	23
20. Phosphate concentration parameters in the water column	13	15 N/A	15	15	13	15	15	15
21. Chlorophyll pigment concentrations in water bodies	1	5 N/A	1	1	6 N/A	1	1	1
22. Dissolved total and organic nitrogen concentrations in the water column	1	2 N/A	1	1	1	1	1	1
23. Horizontal velocity of the water column (currents)	8	4 N/A	4	8	4	8	4	8

List of P02 Characteristics related to input data sets	Horizontal Coverage UD.APE.1.1	Vertical Coverage UD.APE.1.2	Temporal Coverage UD.APE.1.3	Horizontal Resolution UD.APE.3.1	Vertical Resolution UD.APE.3.2	Temporal Resolution UD.APE.3.3	Thematic Accuracy UD.APE.3.4	Temporal Validity UD.APE.4.1
13. Wind strength and direction	3	3	3	3	3	3	3	3
14. Bird taxonomy-related counts	1	1	1	1	1	1	1	1
15. Cetacean abundance	1	1	1	1	1	1	1	1
16. Fauna abundance per unit area of the bed	1	1	1	1	1	1	1	1
17. Coastal geomorphology	1	1	1	1	7 N/A	6 N/A	7 N/A	6 N/A
18. River flow and discharge	29	29 N/A	29	29	27	27	29	29
19. Nitrate concentration parameters in the water column	20 2	24 N/A	23	23	11 12	23	23	23 1 N/A
20. Phosphate concentration parameters in the water column	1 13 1	15 N/A	15	15	2 13	15	15	15
21. Chlorophyll pigment concentrations in water bodies	1	5 N/A	1	1	6 N/A	1	1	5 N/A
22. Dissolved total and organic nitrogen concentrations in the water column	1	2 N/A	1	1	1	1	1	1 N/A
23. Horizontal velocity of the water column (currents)	8	4 N/A	4 4	8	4	8	4	8

Over a total of 27 P02 characteristics used in the Challenge products, using the “overall score” filter and the minimum number of one red score or 5 yellow scores (Table 6.2), 23 characteristics are not adequate with respect to appropriateness indicators at the scale of the Black Sea (Table 6.3).

All the 27 P02 characteristics used in the Challenge products are presented in Table 6.4 sorted by inadequacy.

Table 6.4 List of 27 P02 characteristics ordered in terms of inadequacy for the appropriateness indicators.

P02 Characteristics	# of Red scores	# of Yellow scores	# of Green scores	number of data sets
1. Zooplankton taxonomy-related abundance per unit volume of the water column	3	1	4	7
2. Zooplankton wet weight biomass	3	1	4	7

P02 Characteristics	# of Red scores	# of Yellow scores	# of Green scores	number of data sets
3. Phytoplankton generic abundance in water bodies	3	2	1	2
4. Temperature of the water column	1	6	1	15
5. Skin temperature of the water column	1	2	2	13
6. Bathymetry and elevation	1	4	3	10
7. Terrestrial mapping	0	7	0	1
8. Administrative units	0	7	1	22
9. Habitat extent	0	7	1	9
10. Fishery characterisation	0	7	1	8
11. Fish and shellfish catch statistics	0	7	1	7
12. Wave height and period statistics	0	7	1	6
13. Wind strength and direction	0	7	1	3
14. Bird taxonomy-related counts	0	7	1	1
15. Cetacean abundance	0	7	1	1
16. Fauna abundance per unit area of the bed	0	7	1	1
17. Coastal geomorphology	0	6	0	7
18. River flow and discharge	0	6	1	29
19. Nitrate concentration parameters in the water column	0	6	1	24
20. Phosphate concentration parameters in the water column	0	6	1	15
21. Chlorophyll pigment concentrations in the water bodies	0	6	1	3
22. Dissolved total and organic nitrogen concentrations in the water column	0	6	1	2
23. Horizontal velocity of the water column (currents)	0	6	2	8
24. Snow and ice mass, thickness and extent	0	3	3	2
25. Sea level	0	1	4	26
26. Geological sample density	0	0	2	2
27. Chlorophyll pigment concentrations in water column	N/A	N/A	N/A	6

Table 6.4 is presented below graphically as Figure 6.1 as a bar diagram.

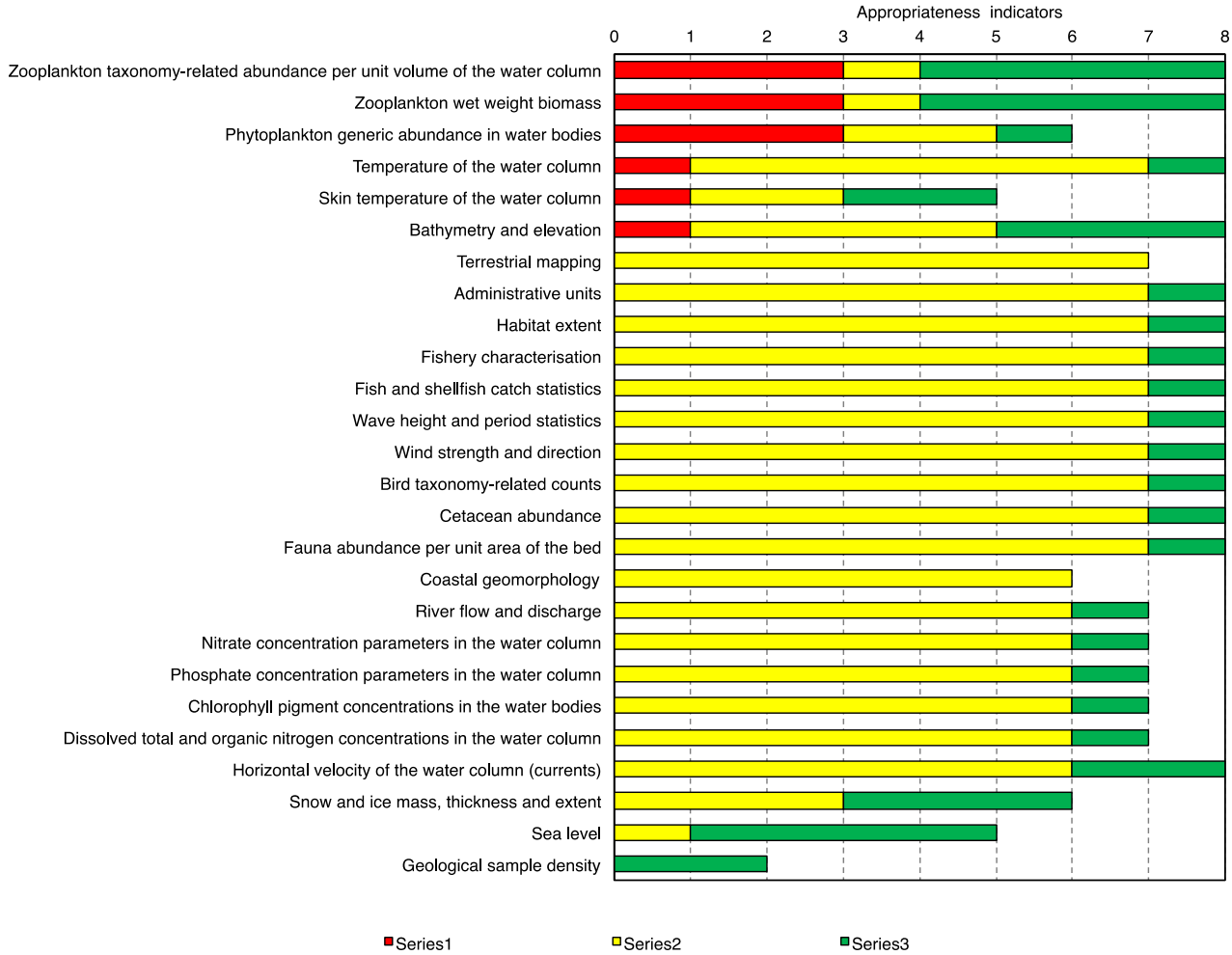


Figure 6.1 Same as Table 6.4 but visualized as a bar diagram

6.2 Analysis of appropriateness indicators for Copernicus and EMODnet services

In this section we analyse the EMODnet and Copernicus service input data used in the Challenge products. Most common negative values are for the horizontal/vertical coverage and resolution indicators meaning that products are still too coarse to be satisfactory for the Challenge products and that coverage is still low, especially for the EMODnet datasets.

Table 6.5 P02 characteristics used by the Challenge products from EMODnet portals and the appropriateness indicators with negative scores, if applicable

P02 Characteristic	Emodnet Portal	Used in:	Negative value Indicators
Bathymetry and Elevation	Bathymetry	BLACKSEA_CH03_Product_1 BLACKSEA_CH03_Product_2	No negative indicators
Coastal geomorphology	Bathymetry	BLACKSEA_CH03_Product_2	No negative indicators
Dissolved total and	EMODnet Chemistry	BLACKSEA_CH09_Product_5	No negative indicators

organic nitrogen concentrations in the water column			
Nitrate concentration parameters in the water column	EMODnet Chemistry	BLACKSEA_CH09_Product_5	Vertical Resolution UD.APE.3.2
Phosphate concentration parameters in the water column	EMODnet Chemistry	BLACKSEA_CH09_Product_6	Vertical Resolution UD.APE.3.2

Table 6.6 P02 characteristics used by the Challenge products from Copernicus service and most common indicator with negative scores

P02 Characteristic	Used in:	Negative value Indicators
Chlorophyll pigment concentrations in water bodies	BLACKSEA_CH08_Product_01	No negative indicators
Horizontal velocity of the water column (currents)	BLACKSEA_CH02_Product_4	No negative indicators
Sea level	BLACKSEA_CH05_Product_1 BLACKSEA_CH05_Product_2	Horizontal Resolution UD.APE.3.1 Temporal Validity UD.APE.4.1
Skin temperature of the water column	BLACKSEA_CH01_Product_1 BLACKSEA_CH04_Product_01 BLACKSEA_CH04_Product_13	Temporal Coverage UD.APE.1.3 Temporal Validity UD.APE.4.1
Temperature of the water column	BLACKSEA_CH09_Product_5	Vertical Resolution UD.APE.3.2

7. Analysis of Challenge targeted products quality

In this section we will analyse and discuss the appropriateness indicators for 141 Challenge Targeted Product components (out of 61 products).

7.1 Evaluation of Targeted Products from appropriateness indicators

As for the availability indicators we will display here the scores for each indicators across all Challenges products. The picture emerging from the TDP appropriateness indicators, shown in Fig. 7.1, is that most of the products have consistent quality with respect to the DPS requirements; the largest TDP inadequacy are linked to horizontal coverage and resolution and to temporal validity.

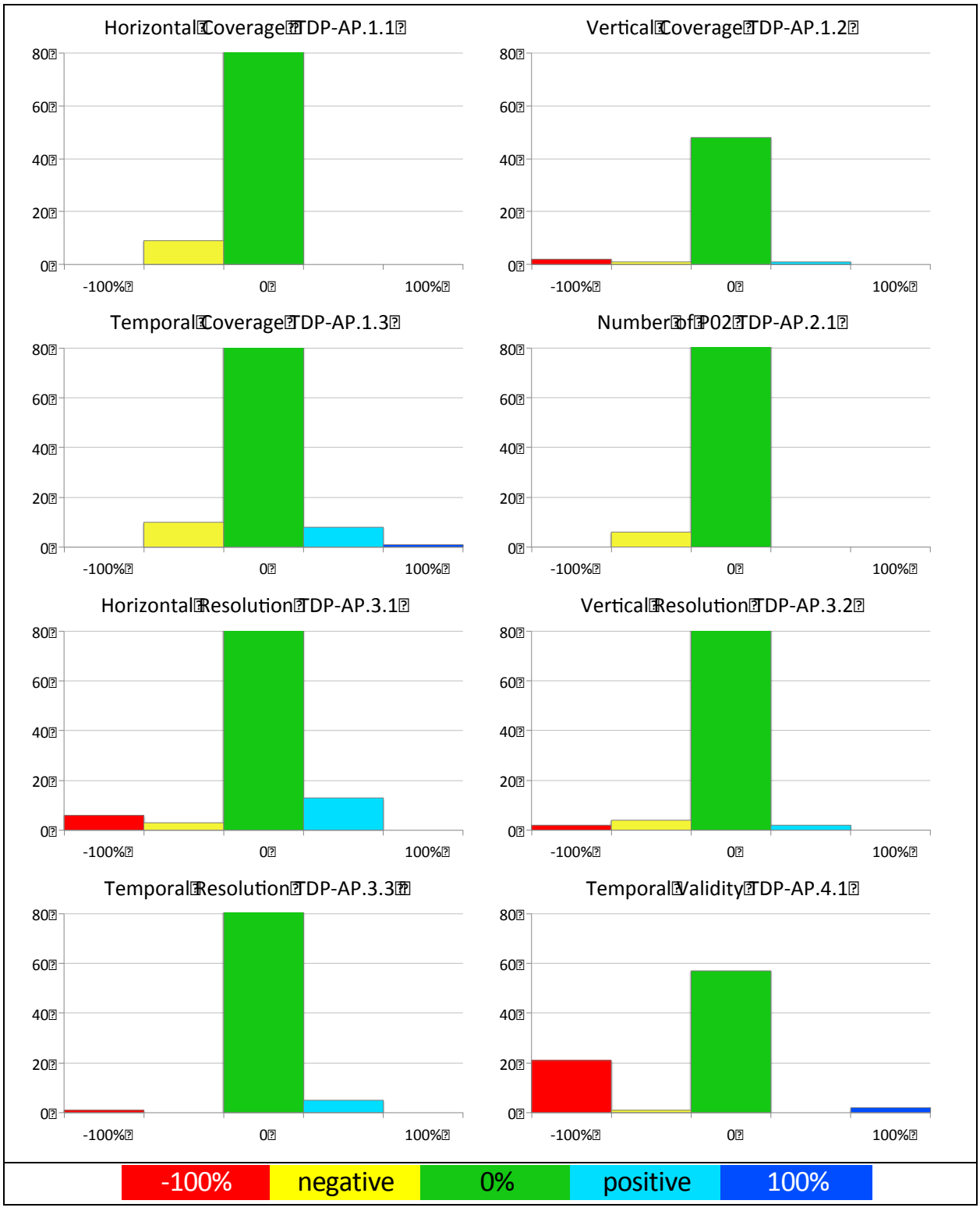


Figure 7.1: TDP appropriateness indicator score distributions (61 products, 141 components).

7.2 Evaluation of Targeted Products from expert opinion

The objective of this internal project survey is to provide an expert evaluation of the "fitness for purpose" of the Targeted Products. The coordinator asked the challenges teams to answer to the following points:

1. Assign an overall product quality score with respect to scope (fitness for purpose) and explain why according to the scale in Table 7.2.1.
2. Explain what is (are) the most important characteristic(s) for the Targeted Product quality (if all characteristics are important please say so);
3. Explain what is (are) the quality element(s) (see Annex 1) of the most important characteristic(s) that affects the Targeted Product quality;
4. Explain the limitations on the quality of Targeted products due to the input data set used;
5. Explain which characteristics "fails the most" to meet the scope of the Targeted Product;
6. Provide an expert judgement to describe for each Targeted Product the most important gaps in the input data sets.

Table 7.2.1 Targeted Products quality scores and their meaning.

SCORE	MEANING
1	EXCELLENT → it meets completely the scope of the Targeted Product
2	VERY GOOD → it meets more than 70% of the scope of the Targeted Product
3	GOOD → it meets less than 70% of the scope of the Targeted Product
4	SUFFICIENT → it does not really meet the scope but it is a starting point
5	INADEQUATE → it does not really fulfil the scope, not usable

The detailed answers to these questions are documented in Annex 5. Table 7.2.2 summarizes the quality scores given by the project experts and Table 7.2.3 shows the scores for each TDP. The Targeted products with lowest "fitness for purpose" are:

1. Ch04 - Climate products encounter the largest problem since of the temperature measurements at surface, 500 m and bottom depth over past 50 years and 100 years are non-uniform in time and space and do not permit to create the consistent maps of temperature trends over the Black Sea. The same problem was reported for the observations of the Black Sea ice coverage for the 50-year period (1966-2015) and the 100-year period (1916-2015).
2. Ch05 - Coasts reported gaps on the sea level and sediment mass balance data for the past 10, 50 and 100 years periods.
3. Ch09 - River inputs reported a lack of information on the eel and salmon biomass in the Black Sea Rivers.
4. Ch10 - Bathymetry reported gaps in the input data sets related to geographical coverage, as the data from the bathymetric surveys cover only 5% of the sea basin area.
5. Ch11 - Alien Species produce low accuracy products since the data is non-uniform in time and space.

Table 7.2.2 Summary of the quality scores associated to each Targeted Products according to the expert's evaluations.

TP	CH1	CH2	CH3	CH4	CH5	CH6	CH7	CH8	CH9	CH10	CH11
1	1	2	3	1	1	1	3	2	1	2	4
2	1	2	2	2	3	3	3	2	1	2	4
3	1	3		2	3	2			1	2	4
4		1		5	3				1	4	4
5		1		5	4				1		4
6				5	5				1		
7				5	5				5		
8				5	5						
9				5	5						
10				1	5						
11				5							
12				5							
13				1							
14				2							
15				2							
16				2							
17				4							
18				3							

Table 7.2.3 Appropriateness indicators according to expert's evaluations of Targeted Products.

TDP	Name	General expert score	Horizontal Coverage APE.1.1	Vertical Coverage APE.1.2	Temporal Coverage APE.1.3	Horizontal Resolution APE.3.1	Vertical Resolution APE.3.2	Temporal Resolution APE.3.3	Thematic Accuracy APE.3.4	Temporal Validity APE.4.1
Ch01_01	A high resolution wind-wave-tides database for the Black Sea area with complementary data for bathymetry, geology, ecosystem and habitats	excellent								
Ch01_02	Assessment of the available database	excellent								
Ch01_03	Assessment of the confidence limits of the data sets for the test regions	excellent								
Ch02_01	List, position and boundaries of Black Sea network of marine protected areas using IUCN classification	very good								X
Ch02_02	Habitat types and mapping of Black Sea network of marine protected areas	very good	X							
Ch02_03	Biodiversity of Black Sea network of marine protected areas	good	X							
Ch02_04	Qualitative analysis of connectivity between MPAs as seasonal maps of sea surface currents [m/s]	excellent								
Ch02_05	Qualitative analysis of connectivity between MPAs as seasonal maps of sea surface temperature [deg C]	excellent								
Ch03_01	Oil Platform Leak Bulletin released on 11 May 2016, fast release, 24h after the incident declared on 10th May 2016 by DG MARE	good								X
Ch03_02	Oil Platform Leak Bulletin released on 11 May 2016, fast release, 72h after the incident declared on 10th May 2016 by DG MARE	very good								
Ch04_01	Map of the change of the average temperature over 2006-2015 period (10 years) - At surface	excellent								

TDP	Name	General expert score	Horizontal Coverage APE.1.1	Vertical Coverage APE.1.2	Temporal Coverage APE.1.3	Horizontal Resolution APE.3.1	Vertical Resolution APE.3.2	Temporal Resolution APE.3.3	Thematic Accuracy APE.3.4	Temporal Validity APE.4.1
Ch04_02	Map of the change of the average temperature over 2006-2015 period (10 years) - At mid water column (500m)	very good								X
Ch04_03	Map of the change of the average temperature over 2006-2015 period (10 years) - At sea bottom (1500m)	very good								X
Ch04_04	Map of the change of the average temperature over 50 years - At surface	inadequate	XX		XX	XX		XX		
Ch04_05	Map of the change of the average temperature over 50 years - At mid water column (500m)	inadequate		XX	XX		XX	XX		
Ch04_06	Map of the change of the average temperature over 50 years - At sea bottom (1500m)	inadequate	XX		XX	XX		XX		
Ch04_07	Map of the change of the average temperature over 100 years - At surface	inadequate	XX		XX	XX		XX		
Ch04_08	Map of the change of the average temperature over 100 years - At mid water column (500m)	inadequate	XX		XX	XX		XX		
Ch04_09	Map of the change of the average temperature over 100 years - At sea bottom (1500m)	inadequate	XX		XX	XX		XX		
Ch04_10	Map of the average extent of sea ice coverage over 2006-2015 period (10 years)	excellent								
Ch04_11	Map of the average extent of sea ice coverage over 50 years	?	XX		XX	XX		XX		
Ch04_12	Map of the average extent of sea ice coverage over 100 years	?	XX		XX	XX		XX		
Ch04_13	Time series of annual mean temperature - At surface	excellent								
Ch04_14	Time series of annual mean temperature - At mid water column (500 m)	very good			X					
Ch04_15	Time series of annual mean temperature - At sea bottom (1500 m)	very good			X					

TDP	Name	General expert score	Horizontal Coverage APE.1.1	Vertical Coverage APE.1.2	Temporal Coverage APE.1.3	Horizontal Resolution APE.3.1	Vertical Resolution APE.3.2	Temporal Resolution APE.3.3	Thematic Accuracy APE.3.4	Temporal Validity APE.4.1
Ch04_16	Time series of average annual internal energy	very good								
Ch04_17	Time series of total ice cover in sea over past 100 years	sufficient								
Ch04_18	Time series of abundance of three most abundant species of phytoplankton	good				X		X		
Ch05_01	Sea level rise (trend) from altimetry for the last 10 years (2006-2015)	excellent								
Ch05_02	Regional sea level time series and trend for 11 sub-regions for the past 10 years (2006-2015)	good				X		X		
Ch05_03	Regional sea level time series and trend for 5 coastal sub-regions for the past 50 years (1966-2015)	good			X	X		X		
Ch05_04	Regional sea level time series and trend for 5 coastal sub-regions for the past 100 years (1916-2015)	good			X			X		
Ch05_05	Sea level time series and trend for the past 10 years for each 4 NUTS3 in Turkey	sufficient	XX					XX		
Ch05_06	Sea level time series and trend for the past 50 years for each NUTS3 from selected coastal stations	inadequate	XX		XX					
Ch05_07	Sea level time series and trend for the past 100 years for each NUTS3 from selected coastal stations	inadequate	XX		XX					
Ch05_08	Sediment mass balance trend for the last 10 years (2006-2015)	inadequate	XX		XX					
Ch05_09	Sediment mass balance trend for the last 50 years (1966-2015)	inadequate	XX					XX		
Ch05_10	Sediment mass balance trend for the last 100 years (1916-2015)	inadequate	XX					XX		

TDP	Name	General expert score	Horizontal Coverage APE.1.1	Vertical Coverage APE.1.2	Temporal Coverage APE.1.3	Horizontal Resolution APE.3.1	Vertical Resolution APE.3.2	Temporal Resolution APE.3.3	Thematic Accuracy APE.3.4	Temporal Validity APE.4.1
Ch06_01	Collated data set of landings, fish and shellfish, by species and year	excellent								
Ch06_02	Collated data set of discards, by species and year	good								X
Ch06_03	Collated data set of by-catch, by species and year	very good	X		X					X
Ch07_01	Extent of fisheries trawlers (bottom trawling) : computed from Vessel Monitoring System Dataset (2012-2015)	good	X		X			X		
Ch07_02	Extent of fisheries impact on the seafloor: sandy habitats where trawling is performed	good	X		X					
Ch08_01	Mapping of seasonal Chlorophyll over 10 years (2005-2014)	very good								X
Ch08_02	Mapping of mean Chlorophyll trend over 10 years (2005-2014)	very good								X
Ch09_01	Monthly mean time series of Water Discharge into Black Sea basin from in situ data (RIVDIS) (1921-1984)	excellent								
Ch09_02	Yearly mean time series of Water Discharge into Black Sea basin from in situ data (RIVDIS) (1921-1984)	excellent								
Ch09_03	Time series of daily river discharge at the discharge point into the Black Sea (1981 - 2010) (computed with Hype model)-	excellent								
Ch09_04	Time series of monthly mean river temperature at the discharge point into the Black Sea (2000-2010)	excellent								
Ch09_05	Time series of River nutrients (nitrate) monthly mean at surface (2000-2010)	excellent								
TDP	**Name**	**General expert score**	**Horizontal Coverage APE.1.1**	**Vertical Coverage APE.1.2**	**Temporal Coverage APE.1.3**	**Horizontal Resolution APE.3.1**	**Vertical Resolution APE.3.2**	**Temporal Resolution APE.3.3**	**Thematic Accuracy APE.3.4**	**Temporal Validity APE.4.1**

Ch09_06	Monthly mean of the phosphorus at river discharge into the Black Sea at surface	excellent								
Ch09_07	Eel/salmon recruitment and escapement	inadequate	XX	XX	XX	XX	XX	XX		
Ch10_01	Black Sea and Azov sea coastlines by digitalization of 14.25 m panchromatic LandSat 7 ETM+ satellite images	very good				X		X		
Ch10_02	Water depth (bathymetric map)	very good				X				
Ch10_03	Priority areas for surveying for safer navigation (wrt to heavy maritime traffic)	very good				X				
Ch10_04	Map of uncertainty in water depth concentrated on Bulgarian part of the Black Sea	sufficient	XX							
Ch11_01	Table of Mnemiopsis leidyi alien species abundance and biomass distribution in the Black sea	sufficient	XX		XX	XX		XX		
Ch11_02	Digital map of Mnemiopsis leidyi alien species abundance distribution in the Black sea	sufficient	XX		XX	XX		XX		
Ch11_03	Digital map of Mnemiopsis leidyi alien species biomass distribution in the Black sea	sufficient	XX		XX	XX		XX		
Ch11_04	Table of Beroe ovata alien species abundance and biomass distribution in the Black sea	sufficient	XX		XX	XX		XX		
Ch11_05	Table of biomass distribution in the Black sea as indicators for impact on the Mnemiopsis leidyi alien species abundance and ecosystem and economy	sufficient	XX		XX	XX		XX		

7.3 Evaluation of P02 characteristics from expert opinion

The results shown in section 6 for the appropriateness indicators show that most of the Upstream Data used to generate the Targetex Data Products are adequate. This is evident in Table 6.4 and Fig. 6.1, only six characteristics score red in some of the indicators. This is due most likely to the fact that people have inserted in the metadatabase a Data Product Specification hat was too close to what actually is available. We believe that this might bias the assessment of which data set is inadequate.
This is also partly due to the fact that scientists tried to use what was available and not what was desireable.

Thus we decided to extract from Annex 5, containing the expert opinions, the P02 characteristics that were discussed to be inadequate for certain appropriateness indicators and the results are shown in Table 7.2.4. Color meaning is the following:
1) good adequacy - green
2) sufficient adequacy - yellow
3) insufficient adequacy - red

Table 7.2.4 Number of P02 characteristics mentioned in expert reviews as a function of major deficiencies in appropriateness indicators

P02 characteristics	*Total number of problems*	Hor. Coverage APE.1.1	Vert. Coverage APE.1.2	Temp. Coverage APE.1.3	Hor. Resolution APE.3.1	Vert. Resolution APE.3.2	Temp. Resolution APE.3.3	Thematic Accuracy APE.3.4	Temp. Validity APE.4.1
Temperature of the water column	***19***	4		7	4		4		
Zooplankton taxonomy-related abundance …	***16***	4		4	4		4		
Zooplankton wet weight biomass…	***16***	4		4	4		4		
Sea level	***15***	3		4	3		4	1	
Snow and ice mass, thickness and extent	***9***	2		3	2		2		
Fish and shellfish catch statistics	***8***	3		3					2
Skin temperature of the water column	***8***	2		2	2		2		
Coastal geomorphology	***6***	3		1			2		
Bathymetry and Elevation	***5***	1			3		1		

P02 characteristics	*Total number of problems*	Hor. Coverage APE.1.1	Vert. Coverage APE.1.2	Temp. Coverage APE.1.3	Hor. Resolution APE.3.1	Vert. Resolution APE.3.2	Temp. Resolution APE.3.3	Thematic Accuracy APE.3.4	Temp. Validity APE.4.1
Fishery characterisation	***5***	2		2			1		
Bird taxonomy-related counts	***2***	1			1				
Cetacean abundance	***2***	1			1				
Chlorophyll pigment concentrations in water bodies	***2***								2
Fauna abundance per unit area of the bed	***2***	1			1				
Administrative units	***2***								2
Phytoplankton generic abundance in water bodies	***2***				1		1		
Habitat extent	***1***	1							
Total	***120***	***32***	***0***	***30***	***26***	***0***	***25***	***1***	***6***

From the analysis of Table 7.2.4 it is evident that now at least 10 characteristics have red scores and more than two yellow scores.
In Table 7.2.5 we list the characteristics that are inadequate from expert opinion and from the metdatadata base indicator scores described in Section 6. We can see that the 6 coming out the objective evaluation from the metadatabase are the same as from expert opinion which evalidates the whole result from section 6.

Table 7.2.5 Number of P02 characteristics that emerge as inadequate for appropriateness indicators from expert opinion and metadatabase scores.

INADEQUATE CHARACTERISTICS FROM EXPERT OPINION	INADEQUATE CHARACTERISTICS FROM METADATABASE INDICATOR SCORES
1. Zooplankton taxonomy-related abundance per unit volume of the water column	1. Zooplankton taxonomy-related abundance per unit volume of the water column
2. Zooplankton wet weight biomass	2. Zooplankton wet weight biomass
3. Phytoplankton generic abundance in water bodies	3. Phytoplankton generic abundance in water bodies
4. Temperature of the water column	4. Temperature of the water column
5. Skin temperature of the water column	5. Skin temperature of the water column
6. Bathymetry and elevation	6. Bathymetry and elevation
7. Coastal geomorphology	
8. Fish and shellfish catch statistics	
9. Snow and ice mass, thickness and extent	
10. Fishery characterisation	

8. Key gaps based on all indicators and expert opinions

Gaps of the monitoring system for the Black Sea are emerging from all the previous analyses and here we will try to make a synthesis of the findings from a combination of the availability, appropriateness indicators and expert opinions.

Such a combination of indicators into a unique combined indicator has been called in Annex 2 the “fitness for use” indicator and we devised also an algorithm to compute the scores. Unfortunately the fitness for use indicator described in Annex 2 does not give rise to reasonable values probably because of the limited numbers of input data sets available that do not allow to compute properly the error standard deviations. As shown in Table 6.1, for the Targeted Data Products have used 27 different characteristics for 253 input data sets, i.e. about 10 data sets per characteristics. Thus it is impossible to have a combined fitness for use indicator calculated as explained in Annex 2.

In order to distil the gaps from a combination of availability, appropriateness and expert opinion, we made an inter-comparison between the inadequate P02 characteristic categories for the availability (see Table 5.2.2) and appropriateness indicators (see Table 6.3) from the medatabase assessment and from the expert opinion (Table 7.2.5).

Table 8.1 The most inadequate P02 characteristics for the availability and appropriateness indicators. Colors indicate characteristics that are present in the three evaluation steps

Not adequate for availability indicators (the threshold is >/= 2 red indicators)	Not adequate for appropriateness indicators (threshold is >/= 1 red indicators)	Not adequate for appropriateness indicators (threshold is >/= 1 red indicators)
1. Air pressure	1. Zooplankton taxonomy-related abundance per unit volume of the water column	1. Zooplankton taxonomy-related abundance per unit volume of the water column
2. Zooplankton taxonomy-related abundance per unit volume of the water column	2. Zooplankton wet weight biomass	2. Zooplankton wet weight biomass
3. Zooplankton wet weight biomass	3. Phytoplankton generic abundance in water bodies	3. Phytoplankton generic abundance in water bodies
4. Phytoplankton generic biomass in water bodies	4. Temperature of the water column	4. Temperature of the water column
5. Phytoplankton generic abundance in water bodies	5. Skin temperature of the water column	5. Skin temperature of the water column
6. Wave height and period statistics	6. Bathymetry and elevation	6. Bathymetry and elevation
7. Spectral wave data parameters		7. Coastal geomorphology
8. Bathymetry and Elevation		8. Fish and shellfish catch statistics
9. Salinity of the water column		9. Snow and ice mass, thickness and extent
10. Atmospheric humidity		10. Fishery characterization

11. Air temperature		
12. Geological sample density		
13. Wind strength and direction		
14. Horizontal velocity of the water column (currents)		
15. Dissolved total or organic phosphorus concentration in the water column		
16. Dissolved oxygen parameters in the water column		
17. Wave direction		

Results are shown in Table 8.1 which is the final result of the second DAR. Given the problems in the evaluation of the appropriateness indicators from the metadatabase and the partial expert opinion for the appropriateness quality elements, we argue that for the Black Sea the number of inadequate characteristics is the maximum number of inadequate characteristics in Table 8.1. The final result is then given in Table 8.2. We argue that gaps in the Black Sea monitoring system are identified by the maximum number of **inadequate characteristics emerging from the scoring system.**

Table 8.2 The most inadequate P02 characteristics from metdatabase indicators and expert opinions

Overall inadequate monitoring characteristics
1. Air pressure
2. Zooplankton taxonomy-related abundance per unit volume of the water column
3. Zooplankton wet weight biomass
4. Phytoplankton generic biomass in water bodies
5. Phytoplankton generic abundance in water bodies
6. Wave height and period statistics
7. Spectral wave data parameters
8. Bathymetry and Elevation
9. Salinity of the water column
10. Atmospheric humidity
11. Air temperature
12. Geological sample density
13. Wind strength and direction
14. Horizontal velocity of the water column (currents)
15. Dissolved total or organic phosphorus concentration in the water column
16. Dissolved oxygen parameters in the water column
17. Wave direction
18. Temperature of the water column
19. Skin temperature of the water column
20. Coastal geomorphology
21. Fish and shellfish catch statistics
22. Snow and ice mass, thickness and extent
23. Fishery characterization

9. Conclusions

This document describes the findings of the EMODnet Checkpoint investigation for the assessment of the basin scale monitoring system data adequacy in the Black Sea.

Assessment of monitoring systems has been traditionally undertaken in oceanography by looking at the use of the input data sets for analyses and forecasts, i.e. for generic information about the ocean state, from physics to biochemistry. An approach that tries to assess the upstream observing system by the quality of the end-user products is missing, desirable and timely.

On the impetus of the EMODnet activities in Europe, DGMARE started an ambitious program, the EMODnet Checkpoint network, that, on the basis of the existing monitoring capabilities evaluates the quality of targeted products to define the monitoring "data adequacy" at the level of the European sub-basins, from the Arctic to the Black Sea.

The Black Sea EMODnet Checkpoint project started in the middle of 2015 and it updated and implemented the quality assessment framework first developed in the Mediterranean Sea. The work was undertaken following two basic principles:

1) use ISO standards to define the quality elements of the assessment;
2) use INSPIRE principles to make available intermediate and final results of the assessment.

Both principles guided the development of a system infrastructure that uses a well-defined vocabulary and a consistent metadata framework that can be used by multiple stakeholders. The Checkpoint Service has the main aim to produce reports, the so-called "Data Adequacy Reports", and this report is one of them, in particular the final one for the Black Sea. Hopefully in the future the reporting will be done regularly, with a report coming every few years (see recommendations).

The information system infrastructure build in the EMODnet Black Sea Checkpoint is similar to the one developed for the Mediterranean and it is based upon three major pillars:

1) a structured metadatabase containing information about: a) input data sets from the monitoring system; b) targeted products description and outputs, all in a standardized way;
2) a set of monitoring assessment indicators developed with ISO standards;
3) a dashboard for computation of indicator or product statistics from the information collected in the metadatabase.

In the Black Sea information was collected for 503 input data sets, covering 42 different characteristics categories, 61 different Targeted products to satisfy 11 Challenges needs: CH1- Windfarm Siting, CH2- Marine Protected Areas, CH3- Oil Platform Leak, CH4- Climate, CH5-Coasts, CH6- Fishery Management, CH7- Fishery Impacts, CH8- Eutrophication, CH9- River Inputs, CH10- Bathymetry, CH11- Alien species.

The final metadatabase is available here: http://emodnet-blacksea.eu/browser/ where all the information about input data sets can be accessed.

The Targeted data products are instead available from each Challenge web page: http://emodnet-blacksea.eu/challenges/.

and a visualization service is available with the Sextant GIS Portal technology.

To summarize, the results presented in this DAR are:

1) a detailed analysis of input data sets both as a function of Challenges and different characteristic categories (Annex 1 and Section 4 of this report).
2) a detailed analysis of indicators for input data sets from the two territories, the availability and the appropriateness (Annex 3 and 4 and Sections 5 and 6);
3) a detailed analysis of the quality of the Targeted products via indicators and expert opinion (Annex 5 and Section 7)
4) an analysis of basin monitoring gaps based upon indicators and expert opinions.

9.1 The monitoring system gaps

From the combined availability and appropriateness indicators, from both the metadatabase and the expert opinion, a list of 22 monitoring characteristics emerge as not adequate. Table 9.1 lists these characteristics and negative indicator score for each of them

Table 9.1 The most inadequate P02 characteristics from metdatabase indicators and expert opinions and the negative quality element associated to them

Overall inadequate monitoring characteristics	Negative indicators: Availability & Appropriateness
1. Air pressure	Easily found, INSPIRE catalog, Visibility of data policy, Readiness, Responsiveness
2. Zooplankton taxonomy-related abundance per unit volume of the water column	Data delivery, Pricing, Readiness, Responsiveness Horizontal coverage, Temporal coverage, Horizontal resolution, Temporal resolution, Temporal validity
3. Zooplankton wet weight biomass	Data delivery, Pricing, Readiness, Responsiveness Horizontal coverage, Temporal coverage, Horizontal resolution, Temporal resolution, Temporal validity
4. Phytoplankton generic biomass in water bodies	Visibility of data policy, Pricing, Readiness, Responsiveness Appropriateness:
5. Phytoplankton generic abundance in water bodies	Visibility of data policy, Data delivery, Readiness, Responsiveness Vertical coverage, Temporal coverage, Temporal validity
6. Wave height and period statistics	Easily found, INSPIRE catalog, Data delivery
7. Spectral wave data parameters	Easily found, INSPIRE catalog, Data delivery
8. Bathymetry and Elevation	Data policy, Pricing, Responsiveness Horizontal coverage
9. Salinity of the water column	Easily found, INSPIRE catalog, Data delivery

Overall inadequate monitoring characteristics	Negative indicators: Availability & Appropriateness
10. Atmospheric humidity	Easily found, INSPIRE catalog, Data delivery
11. Air temperature	Easily found, INSPIRE catalog
12. Geological sample density	Easily found, INSPIRE catalog
13. Wind strength and direction	INSPIRE catalog, Data delivery
14. Horizontal velocity of the water column (currents)	Easily found, INSPIRE catalog
15. Dissolved total or organic phosphorus concentration in the water column	Visibility of data policy, Responsiveness
16. Dissolved oxygen parameters in the water column	Visibility of data policy, Responsiveness
17. Wave direction	Easily found, INSPIRE catalog
18. Temperature of the water column	Horizontal coverage, Temporal coverage, Horizontal resolution, Vertical resolution, Temporal resolution
19. Skin temperature of the water column	Temporal validity
20. Coastal geomorphology	Horizontal coverage
21. Fish and shellfish catch statistics	Horizontal coverage, Temporal coverage
22. Snow and ice mass, thickness and extent	Temporal coverage
23. Fishery characterization	Horizontal coverage, Temporal coverage

9.2 Recommandations for the future development of the service

The EMODnet Checkpoint concept is a unique and innovative approach, developed and implemented by DGMARE in the European regional Seas. Synthetically, the Checkpoint tries to show “how monitoring meets the needs of public and private users” generating Challenge Products where monitoring data are used in a practical way. In other words this could be the quality assessment framework for the future marine data assembly and forecasting systems in Europe.

Implementing the Checkpoint concept requires a methodology covering all assessment aspects which are:

1. objectivity,
2. quantitative analysis,
3. verifiable and traceable analysis.

A future, sustainable EMODnet Checkpoint activity should be the development and maintenance of a “Checkpoint Network service” that meets all these assessment aspects for all the European Seas. It is suggested to follow two main rules:

- Use INSPIRE principles (2007). The Checkpoint Network services should be configured to discover, transform, view and download the Use Case Products and the input data sets that have been used to generate them.

- Use concepts from EEA Core set of indicators (2005). These concepts will be useful in order to: 1) prioritize improvements in the quality and coverage of data flows; 2) enhance comparability and traceability of assessment information.

Harmonization and upgrade of the “Checkpoint Network service” developed in the 2013-2018 phase is needed because:

1. The monitoring systems evolve in time and every few years there is a need to re-assess;
2. more Use Case Products are needed to cover more user needs and enlarge the assessment statistics;
3. there is a need to establish strong & permanent links with intermediate and end users from industry to public authorities on the basis of Use Case Products.

The “Checkpoint Network service” should evolve in an EMODnet authoritative network service, as the EMODnet Thematic Portals are, to assess periodically the monitoring systems at the European sea basin scales. The continuation of the Checkpoint network could increase the statistical database, thus reducing uncertainties in the indicator analysis. Furthermore it could promote new and user-driven indicators, providing traceability of the assessments and finally supporting the evolution and setting up of the European Ocean Observing System (EOOS).

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