CHAIRE COMPTABILITÉ ÉCOLOGIQUE

Working paper

# Experimentation of marine ecosystems biophysical extent and condition accounts in France

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This technical report presents the experimental biophysical marine ecosystems accounts in France in the context of the H2020 MAIA project. It specifically deals with the spatial data management architecture and presents the results for the experimentation of extent account and condition account for the marine environment of the French metropolitan Exclusive Economic Zone.

MAIA Mapping and Assessment for Integrated ecosystem Accounting

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Talents d'une planète soutenable

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# Abbreviations and acronyms

**BSU**.......... Basic Spatial Unit
**CGDD**.......... Commissariat général au développement durable
**CIRED**.......... Centre International de Recherche sur l'Environnement et le Développement
**DCSMM**.......... Directive stratégique pour le milieu marin
**DSF**.......... Documents Stratégiques de Façades
**EAA**.......... Ecosystem Accounting Area
**EA**.......... Ecosystem Asset
**EEZ**.......... Exclusive Economic Zone
**EFESE**.......... Évaluation française des écosystèmes et des services écosystémiques
**ET**.......... Ecosystem Type
**EU**.......... European Union
**GDG**.......... Golfe de Gascogne
**INSEE**.......... Institut national de la statistique et des études économiques
**INPN**.......... Inventaire National du Patrimoine Naturel
**MC**.......... Mer Celtique
**MMN**.......... Manche-Mer du Nord
**MNHN**.......... Muséum National d'Histoire Naturelle
**MO**.......... Mer Méditerranée Occidentale
**MSFD**.......... Marine Strategy Framework Directive
**OFB**.......... Office Français de la Biodiversité
**SDES**.......... Service de la donnée et des études statistiques
**SEEA EEA**.......... System of Environmental-Economic Accounting Experimental Ecosystem Accounting
**SHOM**.......... Service hydrographique et océanique de la Marine
**SIMM**.......... Système d'Information Milieu Marin
**SRM**.......... Sous-Region Marine
**UMS PatriNat**.......... Unité mixte de service Patrimoine Naturel

# 1. Introduction

Environmental information is lacking to understand changes in ecosystems and inform management. European Union (EU)'s Marine Strategy Framework Directive (MSFD) and Biodiversity Strategy 2020 (European Commission, 2011) as well as the Helsinki Commission (HELCOM) call upon an integrated economic-ecological assessment of the costs and benefits of improving the state of the marine ecosystem (HELCOM, 2018). The EU's Biodiversity Strategy also requires member states to map and assess the state and economic value of the ecosystems and their services and to promote the integration of these values into an accounting system by 2020.

To produce standardized ecosystem accounts, the System of Environmental Economic Accounting started to produce norms in 2012. The System of Environmental Economic Accounting - Ecosystem Accounting (SEEA-EA) has been adopted as an international statistical standard by the United Nations Statistical Division in March 2021 (United Nations, 2021). This international acknowledgement should help to raise statisticians' and politicians' awareness of the value of integrated ecosystem accounts and to accelerate the development of environmental reporting systems. The production of these ecosystem accounts should ultimately lead to the interoperability of large datasets, the integration of several environmental indicators into a coherent set of spatially explicit accounts, to create holistic information that can be used for management of socio-ecosystem.

This document details the technical elements used to construct a set of experimental biophysical ecosystem accounts and an associated information system for the marine environment in metropolitan France, as part of the H2020 project MAIA[1] , undertaken over a period of two years from 2019 to 2021.

The literature on marine ecosystem accounts is still emerging, with few works on both biophysical accounts and economic accounts (Comte et al., 2022). In the context of the SEEA, a couple of articles are devoted specifically to the marine environment (Lai et al., 2018; Dvarskas, 2019; Hooper et al., 2019; Wang et al, 2018; Franzese et al., 2017; Vassallo et al., 2017). There are several articles on economic aspects of marine natural capital (Fenichel et al., 2020), resource rent (Greaker et al., 2017), or the blue economy (Luazzani et al., 2019), but the connection with the SEEA-EA is missing. With regard to the existing literature on this topic, the value added of this technical note lies in its focus on the integration of different datasets and indicators into a system of marine ecosystem integrated accounts, with a French case-study illustration.

In France, several experiments have been conducted on ecosystem accounts, the associated information system, and the use of environmental information for specific policies: satellite account for marine recreation (Martin et al., 2018); input-output table on restoration of the Seine estuary (Cordier et al., 2011); synthesis on marine accounts in the MSFD (Mongruel et al., 2019) reporting of the costs of environmental degradation for the implementation of the Marine Strategy Framework Directive (Levrel et al., 2014).

This technical note details the steps undertaken to construct such spatially explicit ecosystem accounts, focusing on the extents and conditions accounts of the marine environment in France. First, it describes the architecture of the system of accounts developed, second it details the ecosystem extent account. Third, it describes the condition account and fourth it discusses challenges and ways forward. The monetary accounts are not described here and will be the object of another report.

The construction steps of these marine ecosystem accounts have been presented and discussed in several dedicated seminars and workshops to share progress on the experimentation (Table 1).

1 https://maiaportal.eu



Table 1. List of workshops and seminars to discuss marine ecosystem accounting in the context of the MAIA project

| Workshops | Date | Participants |
|---|---|---|
| Atelier de travail du projet de recherche MAIA au MTES | 10/05/2019 | Harold Levrel (AgroParisTech), Adrien Comte (CIRED - AgroParisTech), Yann Kervinio (CGDD/SEEIDD), Aurélien Oosterlinck (Coordinateur chaire Comptabilité Ecologique), Clément Surun (CIRED - AgroParisTech), Olivier Laroussinie (DML), Olivier Letode (DML), Antonin Vergez (CGDD/SEEIDD), Françoise Nirascou (SDES), Bnoit Bourges (SDES), Bénédicte Guery (DEB/ATAP) |
| MAIA presentation | 12/06/2019 | ONB |
| Réunion MAIA / OFB sur les comptes biophysiques milieu marin | 17/06/2019 | Adrien Comte (CIRED), Harold Levrel (CIRED), Frédéric Quemmerais-Amice (AFB), Diane Vaschalde (AFB) |
| International Marine Ecosystem Accounting Workshop | 10/10/2019 | More than 20 participants |
| MAIA presentation | 18/10/2019 | DML |
| Marine Accounting Webinar | 19/05/2021 | Lars Hein (WUR) Tin-Yu Lai (SYKE), Elina Virtanen (SYKE) & Markku Viitasalo (SYKE); Wenting Chen (NIWA), Liisa Saikkonen (SYKE) Soile Oinonen (SYKE) Michael Bordt (Global Ocean Accounts Partnership / Fisheries and Oceans Canada) ; Eamon O'Connor & Stephen Hynes (National University of Ireland) Adrien Comte (AgroParisTech) & Harold Levrel (CIRED) |
| Colloque de la Chaire Comptabilité Ecologique | 15/06/2021 | More than 100 participants |
| OSPAR Natural Capital Accounting Special Meeting | 13/07/2021 | More than 30 participants |
| Expérimentation de la mise en place de comptes biophysiques et économiques pour les écosystèmes marins en France métropolitaine | 16/04/2021 | UMR AMURE |
| Workshop d'échange autour des innovations en comptabilité écologique pour informer les politiques environnementales : Quelles orientations ? Quelles priorités ? | 27/01/2021 | Chaire comptabilité écologique (H. Levrel, C. Surun, A. Comte)<br>CGDD-SDES (J-L. Pasquier, I Joassard)<br>CGDD-SEVS (A. Vergez, E. Tromeur)<br>Direction des Affaires Maritimes (M. Verdol)<br>CEREMA (O. Laroussinie)<br>OFB-ONB (J. Massetti –remplacé par A. Le Mieux)<br>OFB-Socio-économie (C. Kermagoret, J. Gauthey) |

# 2. Architecture of the ecosystem accounts and associated information system

Ecosystem accounts are not just a set of tables: it is also an infrastructure for integrating diverse databases into a unified framework based on conventions and norms. Figure 1 presents the overall structure of ecosystem accounting in relation with data production (the bottom) and policymaking (the top). While the inclusion of the top or the bottom in the scope of ecosystem accounting is debated[2], we shall focus on the core of ecosystem accounts defined as:

- An integrated and spatialized information system fed with multiple data sources ;
- A set of accounting tables derived from this system through conventional rules.

Making a parallel with economic accounting, we may identify associated components, such as:

- At the bottom, some data can be specifically created to fill specific data needs for accounting (e.g. households consumption surveys in national accounts) ;
- At the top, some indicators can specifically be derived from the accounts through a set of conventional rules (e.g. GDP in national economic accounts or the ecological debt as we shall discuss later on).

One shall note that these components critically shape the core components of ecosystem accounts. Intended indicators (and their use) can determine the definitions, scopes or methodologies used in the account to ensure the relevance and impacts of the accounts produced. Awareness of existing or potential data can also shape the choice of developments and ensure realism of intended developments of the accounts.

Such a system relies on definitions and specifies the desired information very precisely. Ecosystem accounting therefore defines what information is sought in the first place and imputes best available values for the desired information. Often, it will appear that the desired information can only be approximated (e.g. imputing the value of the previous period). Because the framework does not adapt to each new piece of data, it maintains a clear understanding of data lacks or inaccuracy.

Having this in mind, the SEEA-EA can be described as an integrated and spatial monitoring of ecosystems structured according a set of biophysical[3] and monetary[4] accounts. We present in detail how the SEEA-EA is implemented throughout this project, starting from the accounts and pursuing the related information system.

2 And, as a result, the delineations of ecosystem accounting on these frontiers are blurred in the SEEA-EA (2020).

3 extent of ecosystem types, condition of each ecosystem, ecosystem use, actual and potential services (capacity, supply)

4 monetary values associated with actual ecosystem services or the value of ecosystem assets



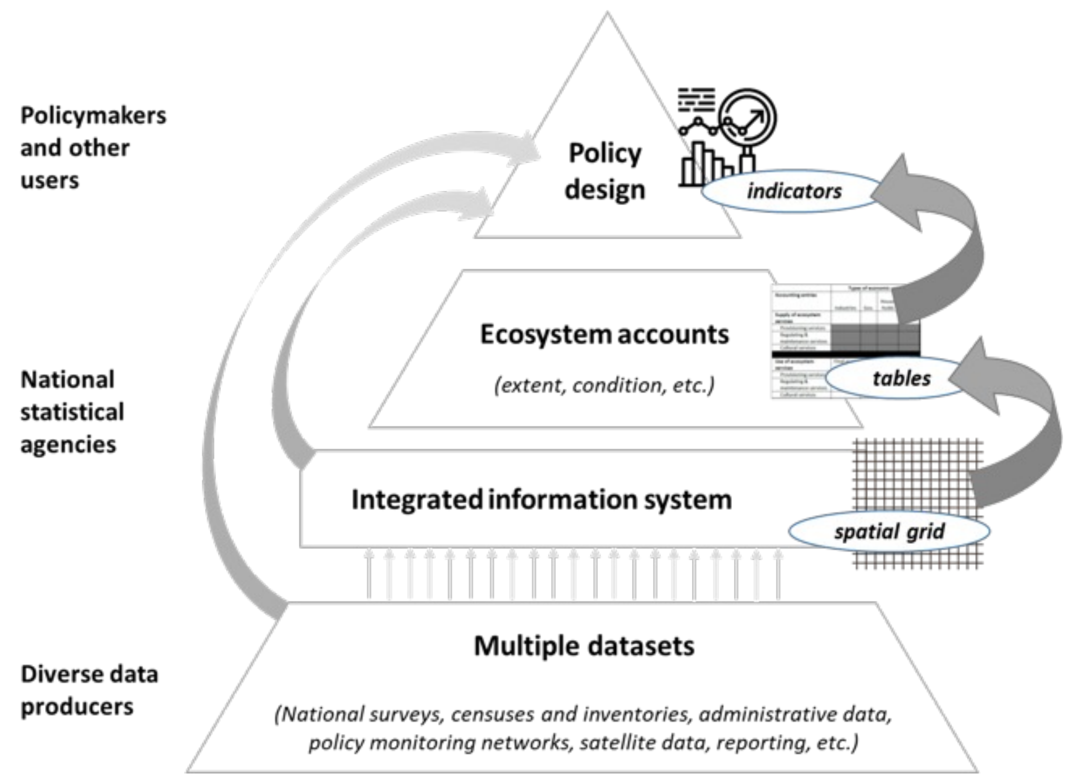



**Figure 1 - Ecosystem accounts are based on an integrated information system and provide structured information for the production of standardised indicators.**

Comment: arrows represent the set of conventional rules through which elements at the upper level are built on the basis of elements of the lower level.

## 2.1 Accounts definition

### 2.1.1 Biophysical accounts

The system of ecosystem accounts developed is structured around biophysical and economic accounts, and differs slightly from the SEEA-EA (Comte et al., 2020; Figure 1). The first account is the extent account, which maps the areas of different types of habitats and is the basis for the other accounts. The other biophysical and economic accounts that complement this system of accounts are outside the scope of this report and will be presented in another publication. The second biophysical account that will be produced in the context of the MAIA project is the condition account, which represents the quality, or state, of the marine habitats described from the extent accounts environment (when the extent account represents the quantity). In this experimentation, this condition account will contain the indicators required to monitor the good ecological status of marine waters defined in the context of the MSFD.

For this account, as well as for the condition account, we follow the definitions given by the SEEA-EA:

"Ecosystem extent accounts organize data on the extent or area of different ecosystem types. Data from extent accounts can support the derivation of indicators of composition and change in ecosystem types and thus provide a common basis for discussion among stakeholders including related to conversions between different ecosystem types within a country. Compilation of these accounts is also relevant in determining the appropriate set of ecosystem types that will underpin the structure of other accounts." (SEEA-EA, 2021, p.32)

"Ecosystem condition accounts. A central feature of ecosystem accounting is its organization of biophysical information on the condition of different ecosystem types within each ecosystem accounting unit. The ecosystem condition account organizes data on selected ecosystem characteristics and the distance to a reference condition to provide insight into the ecological integrity of ecosystems. It will also organize data relevant to the measurement of the capacity of an ecosystem to supply different ecosystem services." (SEEA-EA, 2021, p.33).

## 2.1.2 Clarifying the categories of condition indicators

The SEEA-EA is very flexible in the characteristics to be included in the ecosystem condition account (Maes et al., 2019), and even more so for the marine environment (see definition in glossary). This is the reason why it needs clarifications. In France, specific categories have been developed for the condition accounts, reflecting the recent works of the French Administration regarding the development of ecosystem accounts, the works of the French Ecological Accounting Chaire (Comte et al, 2020), and the conceptual frameworks developed in the EFESE program (Mongruel et al., 2019). These categories of conditions are: heritage, capacity, and functionality (Table 2).

Table 2: description of the three categories of ecosystem condition

| Category of condition | Objective it corresponds to | Indicator of current condition | Indicator of reference condition |
|---|---|---|---|
| Heritage | The objective of conserving remarkable biodiversity, which is expressed in terms of the conservation status of habitat and species, but also, and more generally, in terms of no-net-loss on a set of dimensions. | Indicators regarding the conservation status of targeted habitats and species, detailing the trends of the targeted populations. | All the dimensions on which conservation objectives are specified shall be listed. In principle, each of these features of interest would be captured by an indicator that shall be required not to decrease. |
| Capacity | The objectives of maintaining the capacity of ecosystems to sustainably provide goods and services, which are expressed out of the objectives of other sectoral policies, and that draw the attention on other and complementary features of ecosystems and their functioning as compared to the previous points. | A list of ecosystem goods and services of interest from a sectoral perspective shall be proposed and one or several biophysical indicators that reflect the capacity of ecosystems considered to sustainably provide these goods and services shall be specified. | There are some legal norms which are mentioned for many ecosystem services like the quality of water for bathing, the level of fisheries exploitation, etc. which are mentioned in the MSFD. They reflect political trade-offs on environmental targets. |
| Ecosystem functionality | The objective of maintaining ecosystem functioning, which is a necessary condition to achieve the two previous sets of objectives. Although instrumental to them, it is necessary because of the complexity and the dynamic character of the systems considered; it can be expressed in terms of safe bounds or thresholds on a set of indicators within which the overall functioning of the system is guaranteed. | From the overall functioning perspective, the selection of relevant indicators could traduceresult from the maintenance of current pressures under some threshold or a willingness to strengthen ecosystem characteristics related to its resilience.study of the risk of an irreversible degradation of the ecosystems considered (or resilience) and their determinants. | The reference conditions are based on ecological diagnosis regarding cumulative risks for various components of marine ecosystems, as mentioned in the MSFD. Resilience metrics of ecosystems are also an active area of research that could complement such metrics (connectivity, diversity of species or of genetic material). |



Table 3 below provides a typology of how these categories broadly relate to existing management objectives for marine ecosystems as captured by the descriptor of the EU Marine Strategy Framework Directive (MSFD) as follows.

Table 3. Relationship between categories of ecosystem condition and descriptors of the MSFD

| Category of ecosystem condition | Descriptor MSFD |
|---|---|
| Heritage | Descriptor 1. biodiversity |
| Capacity | Descriptor 3. commercial fish species<br>Descriptor 9. contaminants in seafood |
| Functionality | Descriptor 2. non-indigenous species<br>Descriptor 4. food webs<br>Descriptor 5. eutrophication<br>Descriptor 6. sea floor integrity<br>Descriptor 7. hydrographical conditions<br>Descriptor 8. contaminants<br>Descriptor 10. marine litter<br>Descriptor 11. energy (including underwater noise) |

The descriptors of the MSFD are presented in more detail in table 4.

Table 4. Qualitative descriptors for determining good environmental status (GES) in the MSFD (source:Oinonen et al., 2016)

| MSFD descriptor | Short name | Abbreviation |
|---|---|---|
| Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions. | Biodiversity | D1 |
| Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems | Non-indigenous species | D2 |
| Commercially exploited fish and shellfish | Commercially exploited fish and shellfish | D3 |
| All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity. | Marine food webs | D4 |
| Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters. | Sea floor integrity | D5 |
| Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected. | Human-induced eutrophication | D6 |
| Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems. | Hydrographical conditions | D7 |
| Concentrations of contaminants are at levels not giving rise to pollution effects. | Concentrations of contaminants | D8 |
| Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards. | Contaminants in fish and other seafood | D9 |
| Properties and quantities of marine litter do not cause harm to the coastal and marine environment | Marine litter | D10 |
| Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment. | Energy, including underwater noise | D11 |

Each dimension of ecosystem condition will be accompanied with a reference condition. Such reference levels could arise from existing environmental objectives, standards and limits (Ekins and Usubiaga, 2019). The three concepts are distinguished according to the relative weight of the political and scientific considerations that govern their design (Figure 2). In principle, we will seek to motivate the definition of reference values on the basis of environmental standards (corresponding to legal norms explicitly mentioned in the law), which balance legitimacy (scientific robustness), policy relevance (possible use of the accounts for decision-making), and stability in time (well-defined standards that are not susceptible to change too often, to allow temporal comparisons. They will be motivated on an ad hoc basis depending on the dimensions considered.

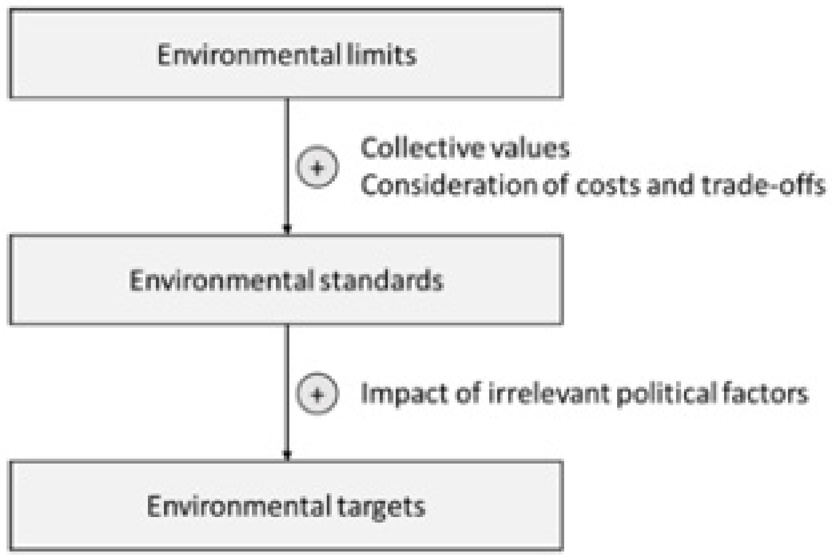



Figure 2. Relationships between environmental limits, standards and targets, adapted from Ekins and Usubiaga (2019).

### 2.1.3 Condition accounting tables

Condition accounting tables are derived from the SEEA-EA guidelines (p. 99) with several adaptations aiming at reinforcing their relevance.

Main adaptations are the following.

- Accounts are organised according to the three categories formerly defined. This structure eases derived indicators and representations.
- Accounts focus on dimensions of interest, as inferred from management targets and other sources.
- They also include and monitor reference levels as derived from existing policy targets. This monitoring allows a transparent identification of the cause of condition improvement (which may be due to a biophysical change in the ecosystem or a change in the reference level used to assess condition).
- Accounts are organised at the level of ecosystem accounting units. They can, but may not necessarily be organised by ecosystem type.

Examples of such condition accounts will be provided in section 4.2.



**Box1: Condition accounting tables**

The SEEA-EA proposes the following ecosystem condition variable account tables (p. 85).

| SEEA Ecosystem Condition Typology Class | Variables | | Ecosystem type | | |
|---|---|---|---|---|---|
| | Descriptor | Measurement unit | Opening value | Closing value | Change |
| Physical state | Variable 1 | | | | |
| | Variable 2 | | | | |
| Chemical state | Variable 3 | | | | |
| Compositional state | Variable 4 | | | | |
| | Variable 5 | | | | |
| Structural state | Variable 6 | | | | |
| Functional state | Variable 7 | | | | |
| Landscape/seascape characteristics | Variable 8 | | | | |

***Table B1.1 - Ecosystem variable account tables as proposed by the SEEA-EA***

Source : SEEA-EA (p. 85).

In this experiment, Ecosystem condition variable accounts are organised at the level of an ecosystem accounting unit. They take the following form.

| Category | Ecosystem type | Dimensions of interest | | Variable value | | Reference level | | Condition value | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *(EUNIS, level 2)* | Name | Indicator | Opening value (2012) | Closing value (2018) | Opening value (2012) | Closing value (2018) | Opening value (2012) | Closing value (2018) | Change |
| Heritage | | | Variable H1 | | | | | | | |
| | | | … | | | | | | | |
| Capacity | | | Variable C1 | | | | | | | |
| | | | … | | | | | | | |
| Functio-nality | | | Variable F1 | | | | | | | |
| | | | … | | | | | | | |

***Table B1.2 - Ecosystem variable account tables used in this experiment***

Source : authors.

## 2.2 Accounts definition

Having described the main features of ecosystem accounts, understood as a broad information system on Nature, we now shall describe as precisely as possible how to implement it in this experiment as well as, potentially, in a deployment at national scale. This endeavour seeks to identify the practical difficulties that may arise when implementing these accounts.

## 2.3 Spatial et temporal units definition

The French marine ecosystem accounts are developed at the French european marine exclusive economic zone (EEZ) scale. This EEZ is divided into ecosystem accounting area (EAA) corresponding to the water under French jurisdiction overlapping with the marine subregions defined in the Marine Strategy Framework Directive[5] (MSFD). At French scale[6] these EEA are defined as presented in the Figure 3: 1) Greater North Sea Sea (Manche-Mer du Nord), 2) Celtic Seas (Mer Celtique), 3) Bay of Biscay (Golfe de Gascogne), and 4) Western Mediterranean Sea (Méditerranée Occidentale). However, another spatial reporting unit, the “Façade Maritime”, is used to report on other marine planning frameworks (“Documents Stratégiques de Façades”, DSF), and could become the scale of reference for presenting the results. There are five reporting units for the DSF, with the Bay of Biscay split in two.

5 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0056

6 https://www.milieumarinfrance.fr/Nos-rubriques/Cadre-reglementaire/Directive-Cadre-strategie-pour-le-milieu-marin


**Figure 3. Visualization of Marine EEA corresponding to the French water of the MSFD marine subregions and their three sub-zones from the coast to the offshore: coastal, intermediate and offshore zones.**

The SEEA EEA Technical Recommendations (United Nations, 2019) published a framework with specific terminology on the spatial dimension of the accounts (Figure 4), which will be the basis for structuring the accounts in this experimentation. It allows the adoption of standards regarding spatial units, named here Basic Spatial Unit (BSU). The BSU is the level at which all the ecosystem information regarding their condition is stored.

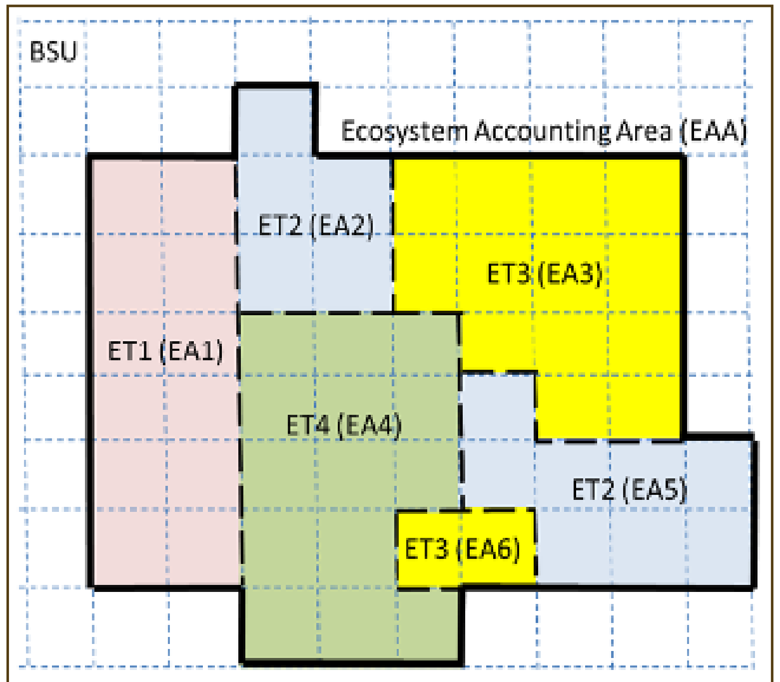



Figure 4: Spatial relationships in the Ecosystem Accounting Area (EAA) from the smallest to the biggest. Basic Spatial Unit (BSU) is the elementary spatial unit, based on a square grid, where each grid cell contains information. Ecosystem assets (EA) are individual, contiguous ecosystems. Ecosystem types (ET) are all EAs of the same type.



The basic spatial unit (BSU) are defined for the whole area of interest. The choice of resolution of this grid depends on the output quality desired, integration of input datasets, computing power constraints, and storage of data. The square grid produced by the CarpeDiem project (Quemmerais-Amice et al., 2020), with a resolution of 1 minute of degree in latitude by 1 minute of degree in longitude is defined as the BSU. It allows us to synthesise, structure and map statistical and spatial information used on EEA into a regular square grid that covers the entire Ecosystem Accounting Area (EAA). In the database, each grid cell was associated with a unique identifier, which made it possible to link these datasets.

This square grid was previously used in spatial and statistical analysis at european french waters scale (Quemmerais-Amice et al., 2020) and was one of the root information used to defined the square grid of reference[7] recommended at French level for implementation of marine public policies that implies broad datasets storage and processing.. It is used for both the seafloor and the water column. As the marine environment is in three dimensions, a grid is set for the seafloor (benthic area) and for the water column (pelagic area). The grid is fit to resolve border delineation between MSFD marine subregions (Annex A).

Our ecosystem types (ET) are the habitats defined in the European Nature Information System (EUNIS) classification for the benthic areas. The EUNIS classification is the European standard that classifies habitats (natural, semi-natural, and man-made) for the terrestrial and marine environments in a hierarchical way (See Annex B for a detail of the typology for several marine ecosystem types). For the pelagic habitat, the ecosystem type is defined in the EUNIS database under the code A7 named "Pelagic habitats". One refinement of this pelagic area delineation is the water bodies defined in the Water Framework Directive, that includes a coastal water body.

Two important features of the accounts are that they cover the entire EAA defined, and that they do not overlap with other EAA (on-land or on the coastline for example) (Annex A). It responds to the principles of accounting to be comprehensive, consistent, and integrative. The limit of what is considered marine and coastal must be explicit. Some administrative boundaries stop at the coastline, while others do not include estuaries and lagoons. Here, they will be taken into the EAAs. Concerning the second principle, the issue is that there are interactions between the land (water basins, estuaries, and coastline) and the ocean, so that datasets of artificialization of the coast, mammal strandings or of pollution of the waters for example could be located outside the EAA. This does not pose an issue at this stage since no land account is in place, but discussions on delineation must happen once the ecosystem accounting extends on land. For pelagic areas, fish stocks as defined in conventions such as OSPAR can be considered as EAAs. Outside of this experiment, it should be possible to extend it to the terrestrial environment and to overseas territories.

## Technical choices

The marine ecosystem accounting areas (EEA) are the French exclusive economic zone (EEZ) further decomposed in:

- 4 façades maritimes in french european waters: Manche-Est-Mer du Nord (MEMN), Nord-Atlantique-Manche Ouest (NAMO), Sud-Atlantique (SA) and Méditerranée (MED).
- Areas to be defined for overseas territories.

In this experiment, marine ecosystem accounts will focus on french european waters.

The basic spatial unit (BSU) is a cell of 1'x1' (around 3,42km² depending on the latitude).

In a full-fledged account, the grid shall be consistent with the grid used to define elementary geographical units of assessment for eutrophication (MSFD descriptor 5) and other existing referential when possible.

The ecosystem types (ET) are the habitats defined in the EUNIS classification system (level 2).

7 https://geo.data.gouv.fr/fr/datasets/cc9c76f5517fd416b9c66b0445599790c5b36df1

An accounting period appropriate for the time-scale (ideally in relation with public decision-making) must be defined in order to specify the pace of updating of the accounts. Often, the goal for defining an appropriate ecosystem accounting period is one year, to follow the accounting period of the System of National Accounts (SNA). Here, an accounting period of six years would be appropriate to follow the marine policy cycles of the MSFD. Data could be updated on a yearly basis in order to report on other issues, including fishing, or eutrophication.

In the case of our specific experimentation, the temporal scales will be different for each account produced, because of the lack of harmonized reporting for the different datasets used. The extent account is particular in that sense, as it is a composite map of various datasets coming from different years. Specific spatial and temporal characteristics of each account are described further in their respective section.

### Technical choices

Marine dataset are poor and not updated on a specific temporal scale by now in France.

The composite map is based on various datasets coming from different years.

Ideally, an accounting period of six years could be appropriate to follow the marine policy cycles of the MSFD.

## 2.4. Data management

The inter-operability of the datasets and the processing of the data to produce accounts will necessitate 1) storage of the datasets in a single location, 2) a common language and software to manage the datasets, 3) some specific rules and convention, as well as a software to process the data, calculate spatial statistics and produce the accounts, 4) metadata to record all useful information on the datasets.

This work integrates datasets available from different public platforms (around 30 tools and databases exist today on the marine environment in France), which are pooled into the Système d'information des milieux marins (SIMM; https://www.milieumarinfrance.fr), in accordance with the "schéma national des données du milieu marin" which defines the schematics of public datasets and its use in an information system. Beyond the SIMM, there are many different databases. some publicly accessible online: SIMM[8], SEXTANT[9], Quadrige[10],Observatoire national de la biodiversité[11]. Others are accessible from research centers: SIPA of Ifremer, economic costs data from MSFD of Ifremer, EFESE, UMS PatriNat of MNHN. Our research team was in direct link with the SIMM and data providers to ensure that this experimentation, which aims at integrating data on the marine environment to produce ecosystem accounts and useful indicators for public policy, is compatible with current and future developments of public datasets on the French marine environment. Data sharing, data access, and communication/confidentiality of the results needs to be agreed upon by all stakeholders before any output is produced and shared. Noticeably, there is a remaining issue on the availability fisheries data on the SIMM, which are currently not included in the SIMM.

For this experimentation, datasets collected from various sources are stored on a physical hard drive located at CIRED[12]. The code to process the data is available in the supplementary materials (Annex D). An adequate computer environment was required for the cleaning, harmonization and synthesis of the data. The database is organized around a relational diagram (Figure 5), which allows analysis of the datasets to produce the various accounts.

8 https://www.milieumarinfrance.fr/
9 https://sextant.ifremer.fr/
10 https://wwz.ifremer.fr/surval/Presentation/Quadrige
11 http://naturefrance.fr/observatoire-national-de-la-biodiversite, Annex C.
12 Centre International de Recherche sur l'Environnement et le Développement : http://www.centre-cired.fr/fr/



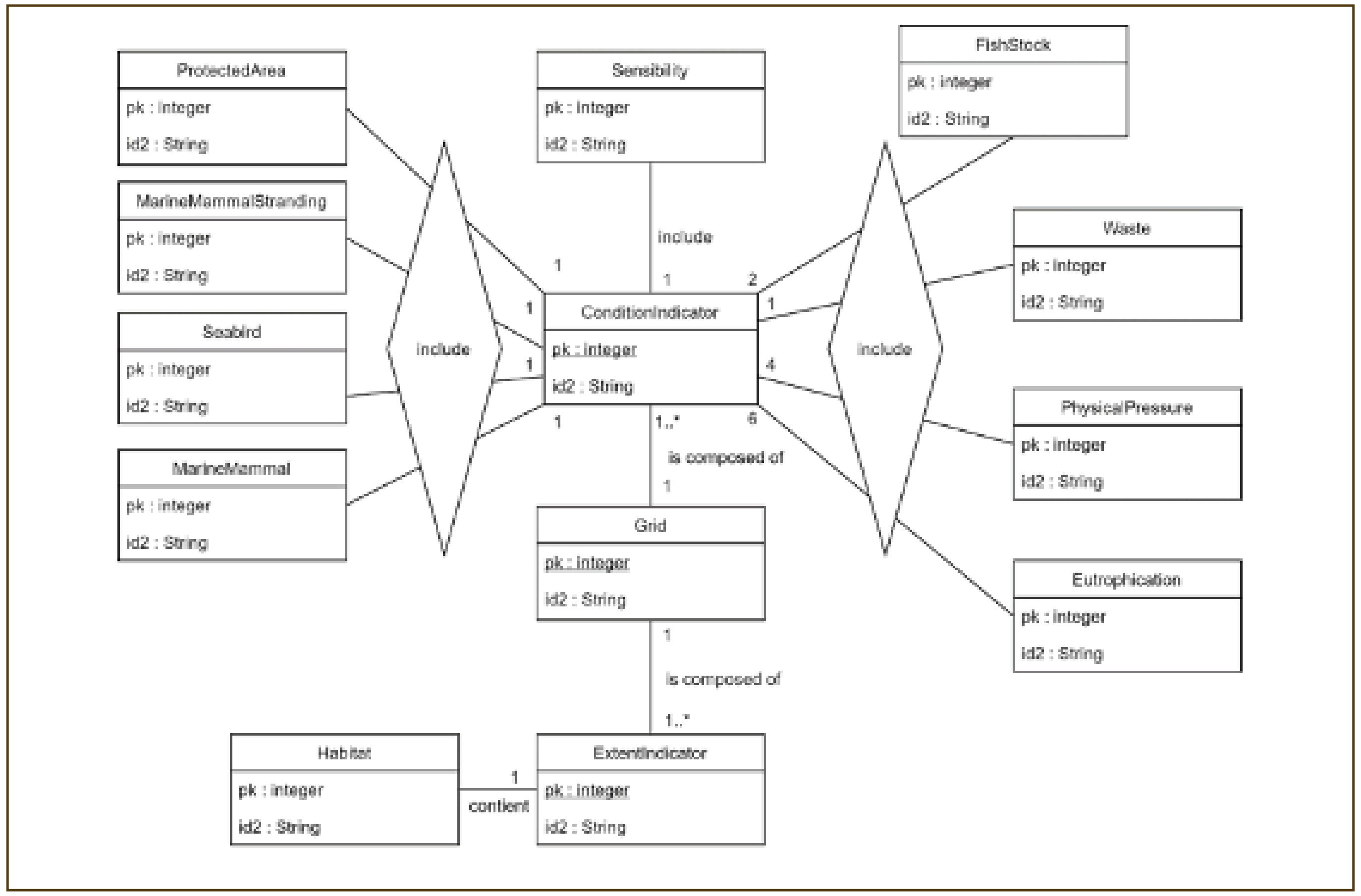



Figure 5. Relational Database Diagram. The grid includes all Basic Spatial Unites

### Technical choices

For this experiment, the database used is the SIMM, except for fisheries. Data providers from the SIMM have been involved in the technical experiment. Only data in public access are used. Datasets collected are stored on a physical hard drive located at CIRED.

## 2.5. Data processing

Information is integrated in a spatially explicit way on each BSU. All the spatial information is mapped using the system WGS 84 (EPSG:4326). Equal area projection is used to ensure all grid cells have the same value when computing accounts from maps.

To process the data and create the accounts and the maps, geospatial analysis can be done using SQL queries and R. The code is made available to allow reproduction of the results (see Annex D). Online tools have been developed to build account tables from maps, notably a web viewer developed by SarVision in the MAIA project[13]. This viewer aims at displaying geospatial information and building accounts from them. The opportunity to use these tools to build our accounts should be explored.

Attribution and aggregation rules have to be set-up to combine diverse datasets into a single grid system (BSU),

13 Will be available on the MAIA project website https://maiaportal.eu

in order to produce readily-available information on biophysical and economic dimensions at the scales of the EEAs. Lots of information will be poorly defined, especially for the pelagic habitats. This will lead to the definition of attribution keys to areas / BSUs: 1) average over the zone, 2) membership to a stock. When information is coarse (a single value for a whole EAA for instance), each BSU will receive the same value. This type of integration rules will be explicit in the metadata. Information will then be aggregated at the level of each EAA to produce policy-relevant sets of accounts and indicators.

Metadata for all datasets are produced, on the basis of the metadata existing for each datasets used as input, as well as the processes used to produce the accounts (spatial scale, temporal scale, aggregation rules). The goal is to allow our database to be available through the SIMM. The GeoNetwork catalog linked to the SIMM, Sextant, offers real interoperability of datasets. The metadata format is the ISO 19115 international norm. Without access to GeoNetwork/GeoSource at our level, the metadata file was constructed around the ISO19115 norm.

### Technical choices

All the spatial information is mapped using the system WGS 84 (EPSG:4326)

When information is coarse (a single value for a whole EAA for instance), each BSU will receive the same value for intensive variables and the overall value weighted by the fraction of the area covered by the BSU for extensive variables.

Geospatial analysis can be done using SQL queries and R

The metadata format is the ISO 19115 international norm



# 3. Ecosystem extent accounts

Contrary to the terrestrial environment, where landscape and habitat diversity are mostly two-dimensional and their evolution can be followed via remote sensing, the marine environment is three-dimensional and remote sensing is ineffective in most of its extent.

## 3.1 Defining Units of Ecosystem Extent

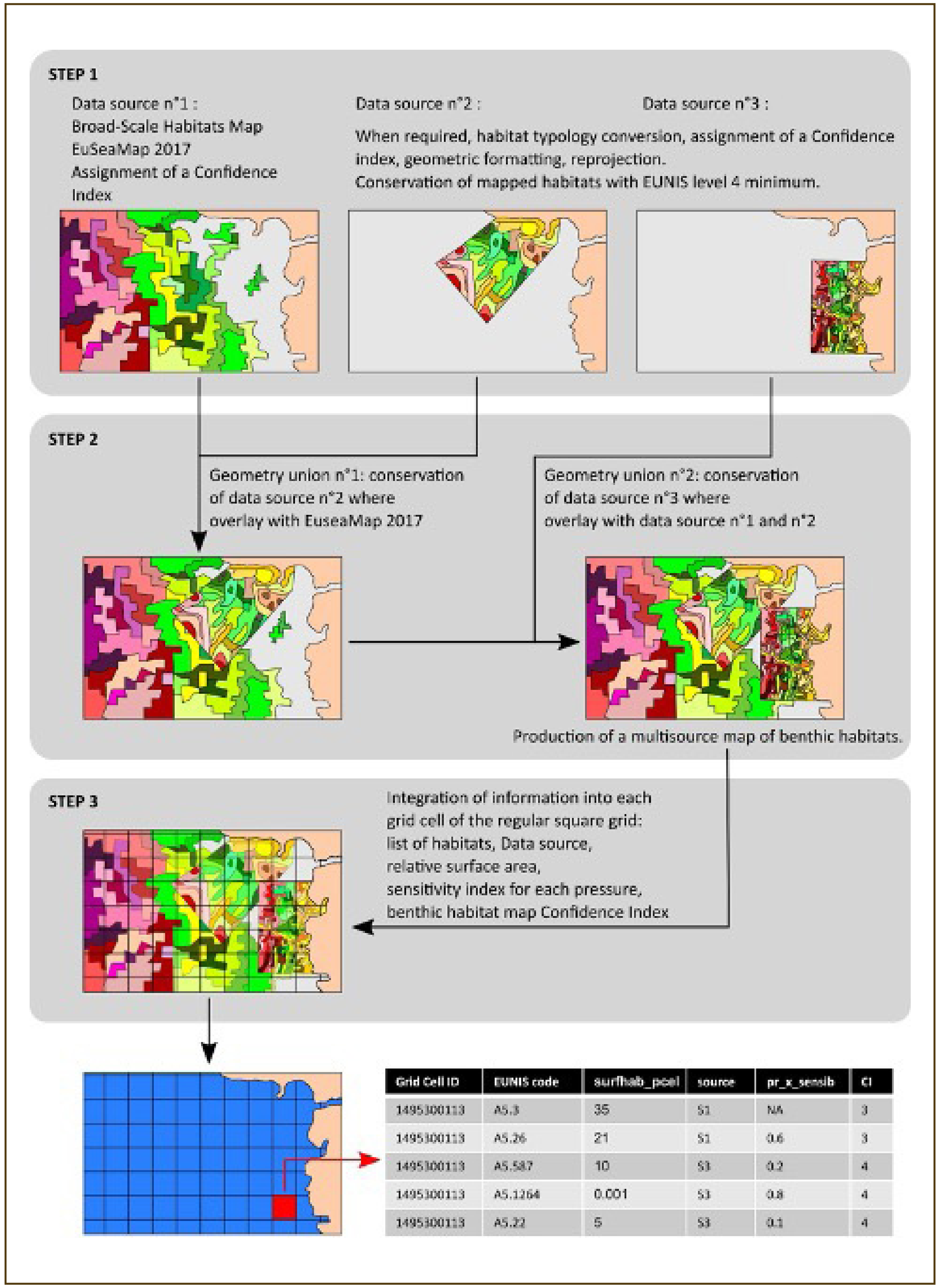
Contrary to the terrestrial environment, where landscape and habitat diversity are mostly two-dimensional and their evolution can be followed via remote sensing, the marine environment is three-dimensional and remote sensing is ineffective in most of its extent.

### 3.1.1 Benthic habitats

A multi-source mapping of benthic habitats covering the entire European French EEZ was conducted during the Carpediem project (Quemmerais-Amice et al., 2020). About 150 data layers from 27 main data sources were compiled, harmonised and integrated to this benthic habitats map, using the EUNIS benthic habitats classification. The milestones of this mapping are presented in Figure 6.

This map is used as the main source of data for calculating the Ecosystem extent account since most of the other benthics habitats maps produced for the last decades in France are focused on specific areas and specific ecosystem components.

However, this map has the disadvantage of being composed of very heterogeneous data sources, both in terms of mapping tools and methodologies, initial habitat typologies, periods covered, spatial resolutions, as well as ground truth and confidence index methods. Therefore, keeping these limitations in mind, the Ecosystems extent account calculation will present an average situation describing the period from 2001 to 2018 based on this existing and available data at the scale of the entire European French EEZ.




| Grid Cell ID | EUNIS code | surfhab_pcel | source | pr_x_sensib | CI |
|---|---|---|---|---|---|
| 1495300113 | A5.3 | 35 | S1 | NA | 3 |
| 1495300113 | A5.26 | 21 | S1 | 0.6 | 3 |
| 1495300113 | A5.587 | 10 | S3 | 0.2 | 4 |
| 1495300113 | A5.1264 | 0.001 | S3 | 0.8 | 4 |
| 1495300113 | A5.22 | 5 | S3 | 0.1 | 4 |

**Figure 6. Main steps of building the multisource map of benthic habitats in European French EEZ (from Quemmerais-Amice et al., 2020)**



For the purposes of this study, it is important to carry out the Ecosystems extent account calculation on the basis of homogeneous EUNIS level for all the mapped habitats. The source data used shows a great diversity in the number of benthic habitats per mesh (Figure 7), which depends, among other things, on the typological resolution at which the initial mapping was carried out. The data source used present the following EUNIS levels :

- **EUNIS level 2:** small set of habitats (7) easy to communicate and build account tables, but very broad categories without biological information. EFESE (the French evaluation of ecosystem services) uses this level 2 classification and adds several habitats important for patrimony (Mongruel et al., 2019).
- **EUNIS level 4:** finer categories that include biological information in soft substrates, but large number of habitats are included, that complicates the communication. At this level of details, we obtain 120 habitats for our study.
- **EUNIS level 5:** finer categories that include biological information in hard substrates.

For the MAIA project we used EUNIS levels 2 and 4 to get a balance between importance of fine-scale information for management and high-level description for the purpose of this case study. Because of the low grid resolutions used here, some of the 120 EUNIS 4 habitats are not found in this study. In grid cells where more than one habitat is found, the grid cell is assigned only the habitat that represents the highest surface area in that cell. Thus, only 86 out of the 120 habitats found in the French EEZ are kept..

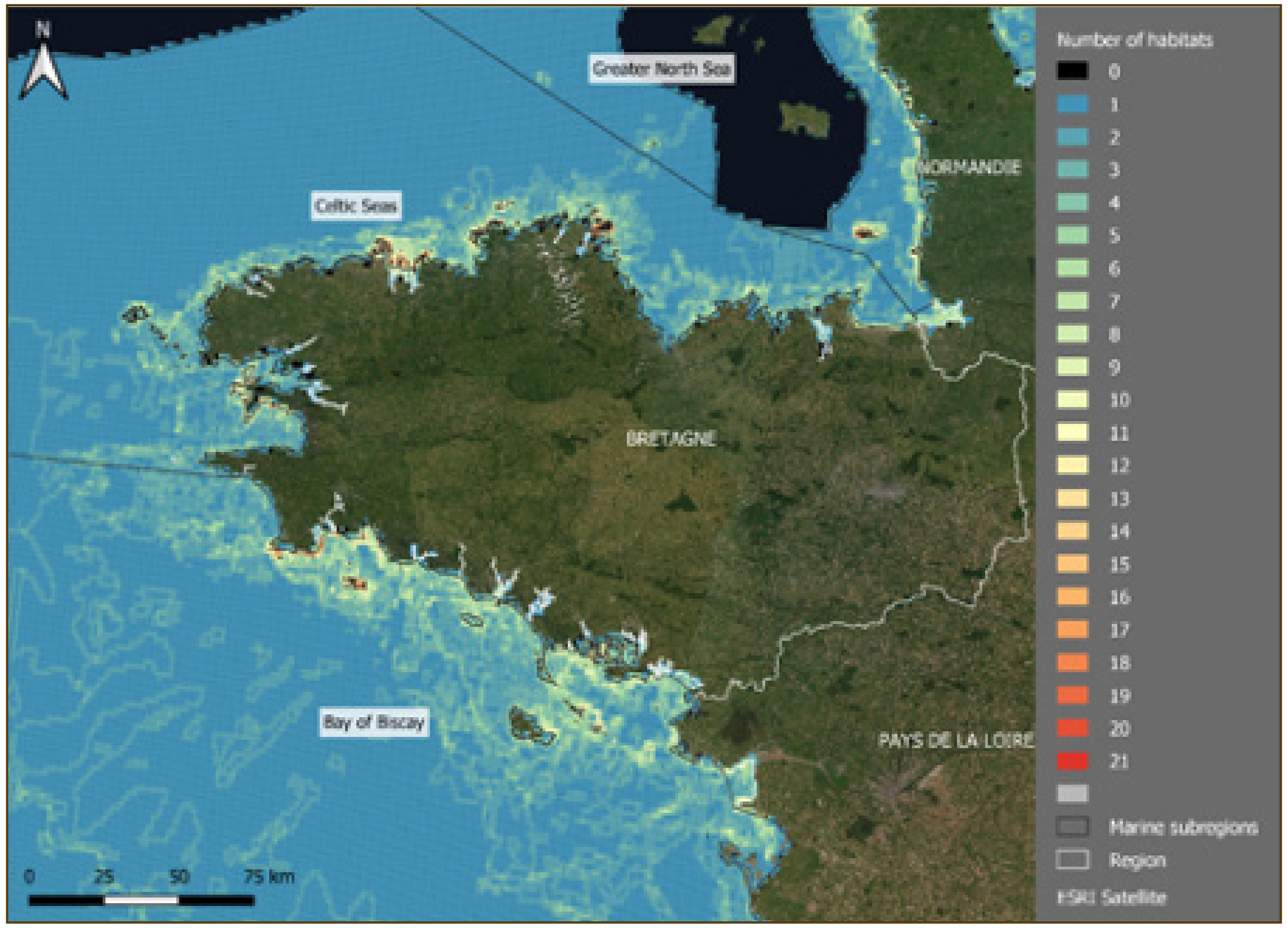



Figure 7. Complexity of the number of marine habitats within the study grid towards the Brittany region

## 3.1.2 Pelagic habitats

The water column is a marine habitat with plankton and pelagic species inhabiting it, which has to be monitored using specific ecosystem types in the marine ecosystem accounts. Three approaches can be adopted to develop ecosystem types for the extent account:

- Water column as a whole (class A7 of the EUNIS classification)
- A "marine landscape" approach (MSFD D7),
- A water body approach (EFESE) - less precise than the marine landscape approach

We chose to take the habitat A7 EUNIS, "Pelagic habitat" to describe the water column as a whole. We also record the different ICES areas for fish stocks assessments, as well as the three domains of the MSFD for recording eutrophication and other pollutants: coastal, intermediary, offshore.

# 3.2 Results

The marine extent spatial accounting for the EEZ, defined from the EUNIS Level 2 is detailed in Figure 8.

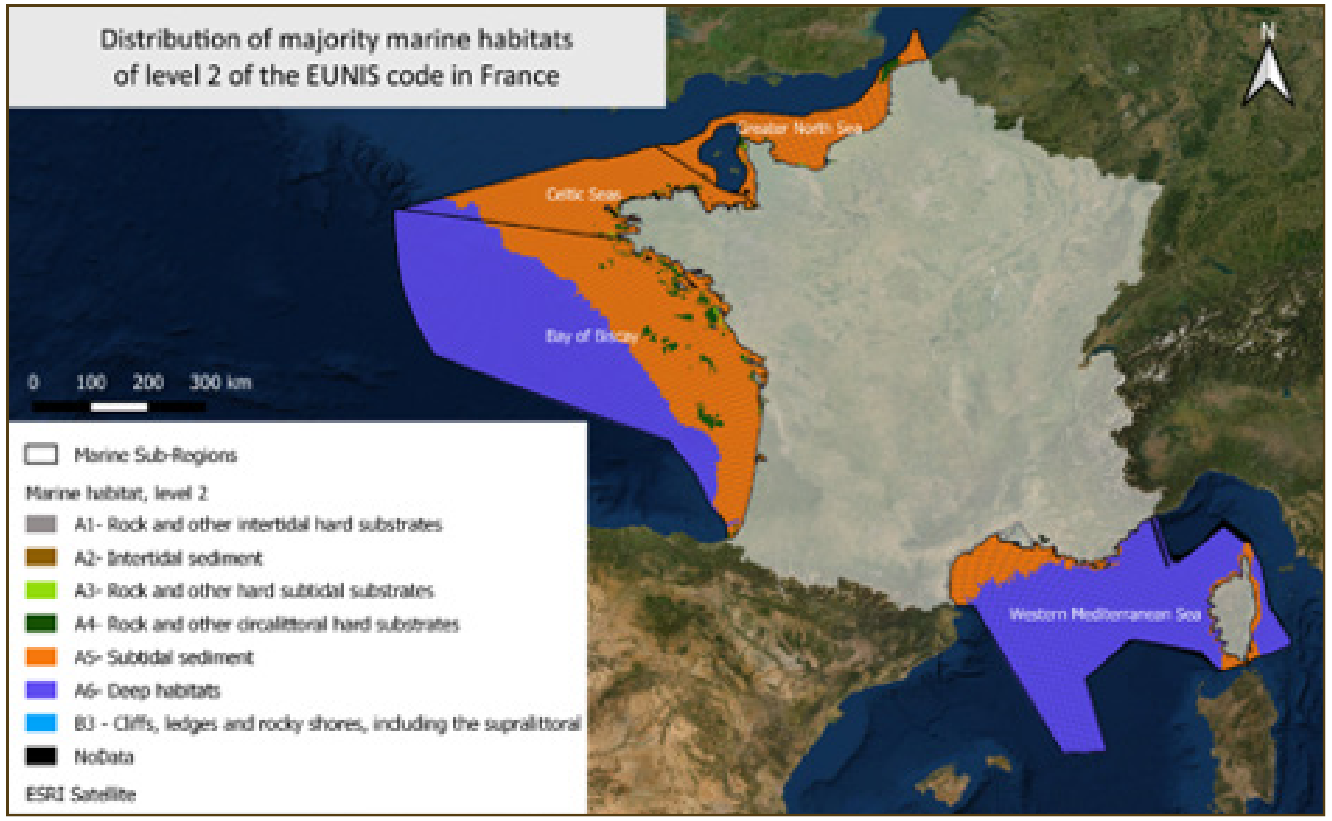



**Figure 8. Map of the extent of marine habitats, EUNIS lvl2. Map projection: Lambert 93, EPSG: 2154**
**Data SCR: WGS84, EPSG: 4326 - Source: French MAIA project, CarpeDiem project**

Using the spatially explicit information, synthetic account tables (Table 5) have been generated to report opening extent, additions, reductions, and closing extent of each habitat types for each EAA and for each accounting period, even if at this stage most of these operations are not possible due to the lack of datasets. The main habitats found in the French EEZ are A5, subtidal sediments, and A6, deep habitats. Together, they account for more than 50% of the extent of the French EEZ. This pattern holds across marine sub-regions, with some differences. The A6 is only found in offshore locations, mostly in the Atlantic and Mediterranean sub-regions.

In this project, the extent account is static, and no evolution can be measured. The evolution of marine habitats will solely be analyzed with respect to their condition. Future projects should aim at producing updated extent maps for marine habitats. The low resolution EUNIS level 2 habitats may not be appropriate



to measure the changes in surface areas of habitats over time. This is shown only for the proof of concept, but accounting tables should be produced at level 4 and higher to have meanings for management.

Table 5. Extent account for benthic habitats of the French EEZ and for each marine sub-region (in square kilometers and as percentages)

| Extent account | | A1 | A2 | A3 | A4 | A5 | A6 | B1 | B2 | B3 | Unité |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Marine Sub-regions | Greater North Sea | 49.434 | 195.557 | 253.384 | 997.776 | 27379.605 | | 0.083 | 0.005 | 0.273 | $km^2$ |
| | Celtic Seas | 24.430 | 158.554 | 599.041 | 868.227 | 39603.796 | 2995.866 | 0.095 | | 1.024 | |
| | Bay of Biscay | 72.801 | 188.495 | 730.017 | 5099.928 | 77176.948 | 105020.022 | 0.171 | 0.006 | 0.466 | |
| | Western Mediterranean Sea | 0.419 | 7.829 | 99.388 | 119.812 | 17845.409 | 94894.658 | 0.489 | 0.263 | 0.007 | |
| French maritime space | Exclusive Economie Zone | 147.085 | 550.436 | 1681.831 | 7085.743 | 162005.758 | 202910.546 | 0.838 | 0.274 | 1.771 | |
| Marine Sub-regions | Greater North Sea | 0.17 | 0.65 | 0.85 | 3.34 | 91.68 | | 0.00 | 0.00 | 0.00 | % |
| | Celtic Seas | 0.05 | 0.35 | 1.32 | 1.92 | 87.47 | 6.62 | 0.00 | | 0.00 | |
| | Bay of Biscay | 0.04 | 0.10 | 0.38 | 2.68 | 40.61 | 55.26 | 0.00 | 0.00 | 0.00 | |
| | Western Mediterranean Sea | 0.00 | 0.01 | 0.08 | 0.10 | 15.02 | 79.89 | 0.00 | 0.00 | 0.00 | |
| French maritime space | Exclusive Economie Zone | 0.04 | 0.14 | 0.44 | 1.85 | 42.19 | 52.84 | 0.00 | 0.00 | 0.00 | |

NB: iIn Orange are cells with values above 40% of the whole surface

A focus on the Brittany region has been carried out (Figure 9), at a EUNIS level 3, in order to have an idea of differences in the results we got at different scales and with different levels of definition.

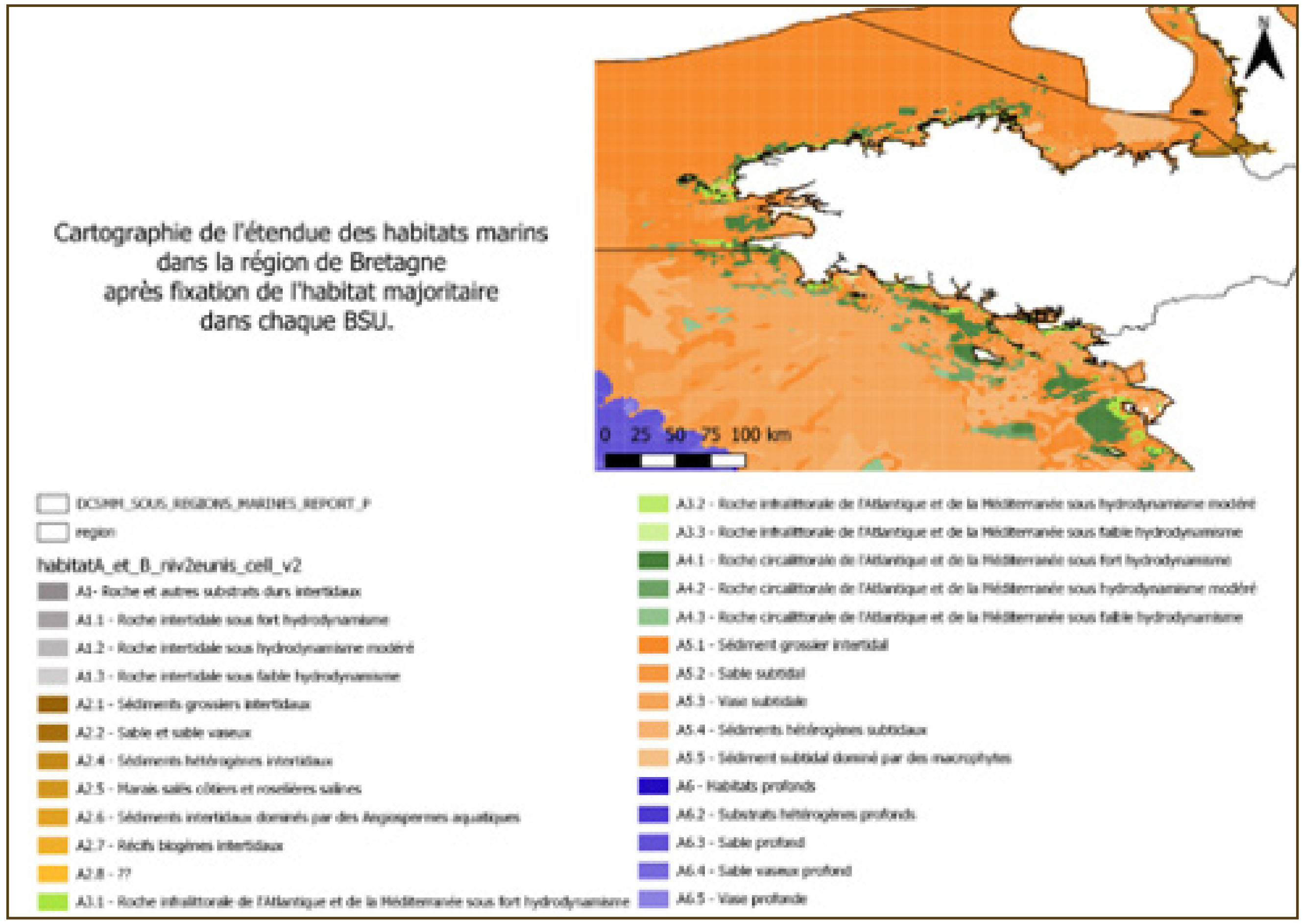



**Figure 9. Map of the extent account, zoom on Brittany, EUNIS level 3**



# 4. Ecosystem condition accounts

The second biophysical accounts that are produced in the context of the MAIA project are the condition accounts, which represent the quality, or state, of marine ecosystems (when the extent account represents the quantity). These condition accounts will cover the dimensions required to monitor progress towards the good ecological status of marine waters and associated environmental targets as defined in the context of the MSFD and possibly other dimensions of interest derived from complementary policy frameworks.

In the first subsection, we define dimensions of interest to categorise indicators of ecosystem condition, and define reference levels that are relevant targets. We then discuss and implement an intended exhaustive census of ecosystem dimensions of interest as revealed by existing management and monitoring targets and discuss how to shape condition accounts from such an exercise. The second subsection presents preliminary condition accounts derived from existing data on a subset of condition indicators within each category.

## 4.1 Defining ecosystem condition indicators and related reference levels

As presented in section 2.1.1, the ecosystem condition characteristics retained for marine ecosystem accounting are dimensions of interest[14] as evidenced by the existence of individual or collective targets and related values. As discussed previously, they can be organised into three categories reflecting, for the ecosystem of interest:

1. the conservation status of relevant species and habitats (heritage category),
2. its capacity to sustainably provide goods and services (capacity category),
3. the insurance that it will remain functional under current disturbance (functionality category).

For each dimension of interest within these categories, the accounts both specify an indicator associated with it[15] and a reference level derived from existing policy targets[16].

We therefore start with a review of existing policy targets. We build and analyse a list of dimensions of interest by reviewing respectively how Good ecological status criteria and Environmental targets are specified in the context of integrated marine ecosystem management in France. We also consider external sources. This leads to a database of dimensions of interest and associated reference levels available as supplementary material to this report at the following link.

We eventually discuss whether such a list could be used to structure useful ecosystem condition accounts and derive recommendations for ecosystem accounting.

14 In this report, dimensions of interest are defined as the dimensions of ecosystems whose monitoring matters for integrated ecosystem management, which can be objectified through a value concept.

15 from which we can derive changes of conditions of the marine environment both for benthic and pelagic areas during the accounting period

16 We will actually focus on environmental standards, mostly derived from an interpretation of the good ecological status and environmental targets designed in the context of implementing the MSFD.

### 4.1.1 Dimensions of interest inferred from MSFD GES criteria

In the MSFD, Good environmental status is defined as "the environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive within their intrinsic conditions, and the use of the marine environment is at a level that is sustainable, thus safeguarding the potential for uses and activities by current and future generations."

In France, the Good ecological status (GES) of marine ecosystems is specified through a ministerial ruling: the Arrêté du 9 septembre 2019 relatif à la définition du bon état écologique des eaux marines et aux normes méthodologiques d'évaluation, consistently with the EU Commission Decision 2017/848 of 17 May 2017 laying down criteria and methodological standards on good environmental status of marine waters and specifications and standardised methods for monitoring and assessment, and repealing Decision 2010/477/EU.

This ministerial ruling fully replaces a previous one taken in 2012. It defines an official nomenclature of primary and secondary GES criteria to be used in national reporting to EU institutions. To carry out our analysis, we build a database of specific dimensions of interest as the dimensions captured by the indicators defined for every criteria (Box 4.1.1-1). For every such dimension of interest, we also report associated target levels when they exist. When a criteria has no indicator associated, we keep the criteria but report a missing indicator.

#### Box 4.1.1-1 - Inferring dimension of interest and reference levels from existing targets

Existing policy targets are defined at multiple scales and level of aggregation and integration[17].

Regarding the issue of scales, relevance targets are those which apply at the level of ecosystem accounting units. In the marine environment, accounting units are consistent with aggregate management targets (the façade maritime) thus many applicable targets are formulated at an accurate scale. Targets defined on smaller areas and greater areas shall, in principle, be included in Documents stratégiques de façade. For those which may be missing, dimensions of interest could be these which, if monitored on the considered accounting area and extended to all relevant areas, would allow the monitoring of the target achievement. When they exist, reference levels could also be derived from existing policy targets applying to smaller areas than the accounting unit. For greater areas, defining reference levels requires implicit judgement regarding the fair allocation across areas which shall be avoided in the sole accounting context (then reported as missing data as long as no further specification is produced), or at least specified in a conventional and transparent way.

Regarding the issue of aggregation and integration, things are more complex when moving from the qualitative description of a criterion and its practical declination through indicators. For comparability and interpretability, we define a dimension of interest according to the following conventions.

(i) When a target is defined on an (aggregate) indicator resulting from the aggregation of (primary) indicators, we shall consider all these primary indicators as defined along dimensions of interest. For instance, a conservation targets could be specified as :

- For a given list of 10 species, no decrease in abundance on each of the 10 indicators
- For a given list of 10 species, no decrease of a indicator reporting the minimum % change of abundance

It is clear that both monitoring strategies feature the same information requirement. Yet, one relies on ten indicators, while the other summarises the situation with a single indicator. In our count, we may seek to get as close as possible to the specific information layers required and would report here 10 dimensions of interests as this is closest to the information requirement.

There are several exception to this

- As all indicators shall in principle be spatialized, aggregation across space is not considered as requiring multiple indicators; for instance " Proportion de sites de baignade dont la qualité des eaux de baignade est de qualité au moins suffisante" count as a single indicator as it can be based on a single information layer mapping the site the baignade and their quality at a given point in time;
- Similarly, as all indicators shall in principle be reported with a definite periodicity, aggregation across time is not considered as requiring multiple dimensions of interest;
- Some well defined aggregative measures such as The IUCN Red list status, or the chemical or enviro mental states of water according to the WFD are considered as primary indicators though they are derived from multiple sources.

(ii) When several indicators are used as complementary proxies of a dimension of interest, we shall report a single dimension of interest. An example of this is the by-catch mortality rate of marine turtles both inferred from stranding or sea observation data in France.

Among the 11 descriptors defining GES in the MSFD directive, 43 criteria are specified, which are themselves declined into 92 indicator groups[18] (the specific dimensions of interest and associated reference levels). This result updates findings from Borja et al. (2014) that focused on the EU decision form 2010, while this analysis includes the EU decision from 2017. For some indicators, the application to different species leads to a drastic increase in the amount of information required. For instance, criterias related to descriptor 3 (commercial species) apply to 101 stocks. Indicators related to species in descriptor 1 also apply to lists of marine birds (86), mammals (17), reptiles (4), fishes (105, not including deep-sea fishes) and cephalopods (2, not including deep-sea cephalopods). In total, we estimate this leads to more than 1600 indicators defining GES of marine waters, among which only 30% define a definite, specific and measurable target and 50% a provisory or incomplete target (table 4.1.1-1)[19].

17 We use integration as defined by Borja et al, 2014 : "The term aggregation is here used for the combination of comparable elements across temporal and spatial scales, indicators and criteria, within a descriptor. The term integration is used for the combination of different elements (e.g., across descriptors). Both combination methods (aggregation and integration) may involve numeric calculations."

18 We could actually say indicator families as some are a type of indicator to decline for every species in a set. Among the 63 criteria, 20 have no indicators associated, and among the 74 indicators specified, 19 were considered as not operational enough for the second cycle of reporting.

19 One can remark that this large number is largely driven by birds: 8 indicators for 86 species, that is almost 700 indicators.

| Descriptor | Fully specified indicator | Partial or provisional indicator | Fully specified reference level | Partial or provisional reference level | Total |
|---|---|---|---|---|---|
| D1 (Biological diversity) | 403 (35%) | 810 (71%) | 173 (15%) | 473 (41%) | 1137 |
| D2 (Non-indigenous species) | 0 (0%) | 5 (100%) | 0 (0) | 1 (20%) | 5 |
| D3 (Fisheries) | 202 (67%) | 202 (67%) | 202 (67%) | 202 (67%) | 303 |
| D4 (Food webs) | 0 (0%) | 4 (100%) | 0 (0%) | 0 (0%) | 4 |
| D5 (Eutrophication) | 10 (83%) | 10 (83%) | 7 (58%) | 10 (83%) | 12 |
| D6 (Sea-floor integrity) | 0 (0%) | 24 (100%) | 0 (0%) | 0 (0%) | 24 |
| D7 (Hydrographical conditions) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 2 |
| D8 (Contaminants) | 89 (98%) | 90 (99%) | 89 (98%) | 90 (99%) | 91 |
| D9 (Sanitary conditions) | 19 (100%) | 19 (100%) | 16 (84%) | 16 (84%) | 19 |
| D10 (Marine litter) | 4 (44%) | 6 (67%) | 0 (0%) | 6 (67%) | 9 |
| D11 (Energy) | 3 (100%) | 3 (100%) | 0 (0%) | 0 (0%) | 3 |
| Total | 730 (45%) | 1173 (73%) | 487 (30%) | 798 (50%) | 1609 |

**Table 4.1.1-1. Specification of dimensions of interest derived from the definition of the GES of marine waters in France.**
**Comment: percentages are defined as the proportion of all indicators of the line.**

We observe a large variability in the maturity and the number of conditions defining GES among descriptors. Descriptors related to specific pre-existing policies (3, 8, 9) feature a large number of specific and measurable targets as evidenced by the existence of fully specified indicators and associated reference levels. Some targets are only defined on regions under the OSPAR convention (marine mammals, invasive species, etc.). Available assessments for fishes in D1 are limited to a few species.

Descriptors requiring conditions at precise levels also imply a greater number of targets. This is especially the case for patrimonial targets. We relate these indicators to the three categories defined in the context of this experiment (table 4.1.1-2). At the level of indicators, we notice that patrimonial stakes lead to a majority of indicators, which is mainly due to the specification of reference levels at the level of specific species and habitats within descriptor 1.



| Category | Patrimonial | Capacity | Functionality | Total |
|---|---|---|---|---|
| Nb of indicators (all potential indicators) | 1088 (68%) | 322 (20%) | 199 (12%) | 1609 |
| Nb of indicators (with provisional reference level only) | 451 (56%) | 218 (27%) | 129 (16%) | 798 |

**Table 4.1.1-2. Distribution of dimensions of interest derived from the definition of GES among categories of ecosystem condition.**
**Comment: percentages are defined as the proportion of all indicators of the line.**

## 4.1.2 Dimensions of interest inferred from MSFD environmental targets

In the MSFD, Environmental targets are defined as “qualitative or quantitative statements on the desired condition of the different components of, and pressures and impacts on, marine waters in respect of each marine region or subregion”. They shall be part of the references taken into account by Member States when establishing and implementing coordinated monitoring programmes for the assessment of the environmental status of their marine waters (art. 11).

In the second implementation cycle, France defined 64 environmental targets further specified through a potential set of 114 indicators. The specification of associated targets is even more advanced as 105 (92%) of these indicators are fully defined and 101 (89%) are associated with an explicit reference level.

| Descriptor | Fully specified indicator | Fully specified reference level | Total |
|---|---|---|---|
| D1 (Biological diversity) | 48 (94%) | 48 (94%) | 51 |
| D2 (Non-indigenous species) | 4 (80%) | 4 (80%) | 5 |
| D3 (Fisheries) | 1 (33%) | 1 (33%) | 3 |
| D4 (Food webs) | 4 (100%) | 3 (75%) | 4 |
| D5 (Eutrophication) | 8 (89%) | 8 (89%) | 9 |
| D6 (Sea-floor integrity) | 9 (100%) | 8 (89%) | 9 |
| D7 (Hydrographical conditions) | 8 (89%) | 8 (89%) | 9 |
| D8 (Contaminants) | 15 (94%) | 14 (93%) | 16 |
| D9 (Sanitary conditions) | 2 (100%) | 2 (100%) | 2 |
| D10 (Marine litter) | 3 (100%) | 3 (100%) | 3 |
| D11 (Energy) | 3 (100%) | 2 (67%) | 3 |
| Total | 105 (92%) | 101 (89%) | 114 |

**Table 4.1.2-1. Specification of dimensions of interest derived from the definition of the ET of marine waters in France.**
**Comment: percentages are defined as the proportion of all indicators of the line.**

Environmental targets lead to identifying dimensions of interest motivated from a diversity of values, as reflected by the identification of dimensions of interests in each category of ecosystem condition, with more emphasis on functionality and less on heritage as compared to what was derived from GES.

| Category | Patrimonial | Capacity | Functionality | Total |
|---|---|---|---|---|
| Nb of indicators derived from environmental targets (all potential indicators) | 45 (40%) | 10 (9%) | 59 (52%) | 114 |

**Table 4.1.3-2. Distribution of dimensions of interest derived among catégories of ecosystem condition.**
**Comment: percentages are defined as the proportion of all indicators of the line.**

Elaborating on the classification presented in appendix I of the EU reporting guidelines (European Commission 2018), we classify each indicator regarding how it is positioned in the causality of ecosystem change (but departing from the DPSIR framework, see box 1.1.2-1). Two-third of potential dimensions of interest derived from GES are formulated on ecosystem state while environmental targets invite considering dimensions closer to the causes of ecosystem degradation. Yet, these targets are operationalized through environmental targets which are another set of policy targets requiring specific monitoring.

| Category | Indirect drivers | Direct drivers | Environmental impacts | State | Total |
|---|---|---|---|---|---|
| Nb of indicators derived from GES (all potential indicators) | 0 (0%) | 335 (21%) | 209 (13%) | 1065 (66%) | 1609 |
| Number of indicators derived from ET (all potential indicators) | 28 (25%) | 60 (53%) | 10 (9%) | 16 (14%) | 114 |

**Table 4.1.2-2. Distribution of level of causality derived from GES and ET.**
**Comment: percentages are defined as the proportion of all indicators of the line.**



### Box 1.1.2-1 - Methodology and definition for attributing dimensions of interest to specific level in the causality chains leading environmental change

The Driver - pressure - state - impact - response framework has been specified in multiple ways since the original specification by the EEA. In our work, we will adopt the following definitions :

- Indirect drivers are the factors that have been shown to cause or alleviate pressures but which may be decoupled, in the context of the MSFD they include economic activities ;
- Direct drivers are the direct factors that cause ecosystem degradation or enhancement and which ca not be decoupled ; pressures and restoration measure both are direct direct drivers of ecosystem change ; they are measures at the level of the activity (e.g. the measured level of end-of-pipe contaminant),
- (Environmental) impacts are the change in ecosystem state resulting from the pressures or restoration measures (e.g. the measured level of 'anthropic' contaminants in the environment or the observed mortality of a species which can be attributed to specific activities); they are explicitly called environmental to be distinguished from the (socio-economic) impacts of the DPSIR framework;
- State are in situ measure of ecosystem state with no specific attribution to human activities (e.g. the overall measure of contaminant in the environment or the abundance of a species).

Finally, (Socio-economic) Impact are measures of changes in human welfare resulting from environmental change and Responses are the measures taken due the environmental change. In our classification, these later are considered as Drivers (e.g. setting marine protected areas are considered as changes in governance, an indirect factor of ecosystem change).

## 4.1.3 Dimensions of interest inferred from other sources

Although the MSFD defines the framework of integrated ecosystem management, the identification of dimensions of interest shall seek to identify the «blind spots» not covered in this framework, either due to unbalanced political powers (some users having more political leeways may induce a focus on specific services from which they benefit most), lapse in policy integration or delay in passing scientific to political arenas. This part could include other other policy frameworks (e.g. SDGs[20] , etc.) and allow considering alerts from scientists (e.g. Steffen et al, 2015 or the literature on weak signals) or stakeholders to complete the picture.

Regarding other policy frameworks, the MSFD requires member states to design policies consistently with other policies. Besides, the strategic environmental assessment of resulting plans forces to ensure (at least) compatibility with existing EU and international regulations (see box 4.1.3-1). Besides, Member States shall at least ensure consistency between these targets and others established in the context of specific national or local regulations. While consistent, this may not cover all dimensions of interest as revealed by these regulations, and stakeholders concerns not reflected in regulation. Such other issues of concern could be recovered from an extended review, including the reports established through the environmental strategic assessment process and reports from the public consultations carried out throughout the process. Such a review was not done in this experiment.

20 Sustainable Development Goal 14, https://sustainabledevelopment.un.org/sdg14 ; Objectifs de développement durable en rapportant de nombreux indicateurs marins https://sdgcompass.org/sdgs/sdg-14/

## Box 4.1.3-1 - EU and international policies explicitly considered in the MSFD process

According to 2014 EU reporting guidelines, MSFD already encompasses targets related to more than 30 existing EU and international regulations, including the following:

1. Bathing Water Directive (76/160/EEC)
2. Birds Directive (2009/147/EC)
3. Drinking Water Directive (80/778/EEC) as amended by Directive (98/83/EC)
4. Environmental Impact Assessment Directive (85/337/EEC)
5. Regulation on contaminants in foodstuffs (EC 1881/2006)
6. Habitats Directive (92/43/EEC)
7. Integrated Pollution Prevention Control Directive (96/61/EC)
8. Major Accidents (Seveso) Directive (96/82/EC)
9. Nitrates Directive (91/676/EEC)
10. Placing of plant protection products on the market (Regulation EC/1107/2007)
11. Sewage Sludge Directive (86/278/EEC)
12. Urban Waste Water Treatment Directive (91/271/EEC)
13. Water Framework Directive (2000/60/EC)
14. Priority substances Directive (2013/39/EU)
15. Floods Directive (2007/60/EC)
16. Prevention and management of the introduction and spread of invasive alien species
17. (Regulation 1143/2014)
18. Waste Framework Directive (2008/98/EC)
19. Directive on National Emission Ceilings for certain pollutants (2001/81/EC)
20. Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals (EC
21. 1907/2006)
22. Common Fisheries Policy and its Data Collection Framework (DC-MAP)
23. EU Biodiversity Strategy
24. Convention on Biological Diversity
25. Convention on Migratory Species
26. UNECE Convention on long-range transboundary air pollution
27. Helsinki Convention
28. OSPAR Convention
29. Barcelona Convention UNEP/MAP
30. Black Sea Convention (Bucharest Convention)
31. Trilateral Wadden Sea Cooperation
32. General Fisheries Commission for the Mediterranean
33. International Commission for the Conservation of Atlantic Tunas
34. North East Atlantic Fisheries Commission
35. International Maritime Organisation (MARPOL, Ballast Water Convention, Antifouling Convention)

### 4.1.4 Discussion and recommendations

A methodic review of existing policy targets allows us to derive a set of dimensions of interests with associated reference levels resulting from an implicit valuation process. Such a dashboard is a good candidate for monitoring the sustainable use of marine ecosystems and therefore marine ecosystem conditions. This exercise leads to identifying a large number of dimensions of interest. Yet, we can argue that all of these dimensions are monitored for a reason as reflected by underlying values. Therefore, the simplification of this dashboard would require dismissing some dimensions, thereby reducing the potential of the information system to support a diversity of views on what matters. Such simplifications shall be left to the political process.

However, parsimony could be obtained by further specifying the underlying values and structuring the dashboard, identifying potential redundancies or possibilities for simplification. An extension of the analysis could intend to review and consolidate this list in this line. Another interesting extension would be to analyse how the existing list of indicators fit into the structure for condition indicators as proposed in the SEEA-EA (see box 4.1.4-1).

## Box 4.1.4-1. Box : The SEEA Ecosystem Condition Typology (ECT)

**Group A: Abiotic ecosystem characteristics**

- Class A1. Physical state characteristics: physical descriptors of the abiotic components of the ecosystem (e.g., soil structure, water availability)
- Class A2. Chemical state characteristics: chemical composition of abiotic ecosystem compartments (e.g., soil nutrient levels, water quality, air pollutant concentrations)

**Group B: Biotic ecosystem characteristics**

- Class B1. Compositional state characteristics: composition / diversity of ecological communities at a given location and time (e.g., presence / abundance of key species, diversity of relevant species groups)
- Class B2. Structural state characteristics: aggregate properties (e.g., mass, density) of the whole eco system or its main biotic components (e.g., total biomass, canopy coverage, annual maximum normalized difference vegetation index (NDVI))
- Class B3. Functional state characteristics: summary statistics (e.g., frequency, intensity) of the biological, chemical, and physical interactions between the main ecosystem compartments (e.g., primary productivity, community age, disturbance frequency)

**Group C: Landscape level characteristics**

- Class C1. Landscape and seascape characteristics: metrics describing mosaics of ecosystem types at coarse (landscape, seascape) spatial scales (e.g., landscape diversity, connectivity, fragmentation)

## Technical choices regarding the selection of dimensions of interest and reference levels

In a full-fledged account, most dimensions of interest can be identified from the definition of GES and environmental targets of the MSFD. In principle, all dimensions so identified shall be monitored as they all reflect existing issues in integrated marine ecosystem management. Also numerous, such monitoring would be performed at low cost as data would have to be generated in the MSFD monitoring program. As they reuse existing reporting categories, this would facilitate the use of accounting tables for reporting.

However, this does not apply to the overseas territories where other reference conditions have to be found (e.g. the WFD).

Also, a fully inclusive information system would consider indicators of heritage, functionality, and capacity from other scientific and normative sources and leave this framework open to scrutiny and discussion. Beyond the indicators established in the context of the MSFD, a specific process could consider complementary claims for other dimensions and indicators to be included. This would foster the inclusiveness of the accounts and provide a basis for policy improvement by identifying existing lack in policy scrutiny.

In these experimental accounts, we will pick up a subset of identified dimensions of interest composed of some indicators in each of the three categories of dimensions of interest.

## 4.1.5. Implementation for preliminary conditions accounts

Out of all identified dimensions of interest and associated reference conditions, we choose a subset of dimensions for the experimental account we carry out. Indicators have to be selected to represent the three categories of conditions. As reporting missing data on dimensions that matter are in itself an important result, the availability of data shall not be a prime concern for the definition of dimensions of interests of the accounts. However, one purpose of this experiment is to give an idea of a piece of accounts as a proof of concept. We therefore also choose to focus on dimensions supported by some spatially explicit datasets.

In France, many institutions are responsible for the collection of datasets on the marine environment. A first scan of projects and databases was conducted to identify possible sources of data, and how they relate to the MSFD descriptors (Table 4.1.5-1). There are discrepancies in the data collection available to construct these indicators. Several indicators are using datasets aggregated over several years (orange in table 7.) while others have time series available (green, table 7). This is problematic to create accounts that are bound in time, and for the update of the accounts in the future. Harmonisation on data collection and delivery is therefore needed to produce meaningful integrated ecosystem accounts.

**Table 4.1.5-1. Available datasets used to construct the extent and condition accounts**

| Account | Indicator category | Indicators | Corresponding MSFD tag | Years of data collection |
|---|---|---|---|---|
| Extent | Marine habitats | Habitats extent | D1C5 | 2010-2018 |
| Condition (heritage) | Birds (Annex E) | Number of species groups, abundance, density, IUCN classification | D1, D1C2, D1C4 | 2011-2012 |
| Condition (heritage) | Marine Mammals | Number of species groups, abundance, density, IUCN classification | D1, D1C2, D1C4 | 2011-2012 |
| Condition (heritage) | Marine mammal strandings | Number of strandings | D1C1 | 2014, 2015, 2016, 2017, 2018, 2019, 2020 |
| Condition (heritage) | Protected areas | Protected areas extent | D1 | 2012 (SPAs), 2013 (NMP), 2016(SIC) |
| Condition (function) | Floating waste | Density, weight | D10C1 | 2011-2012 |
| Condition (function) | Waste on the seabed | Density, weight | D10C1 | 2012, 2013, 2014, 2015, 2016 |
| Condition (function) | Risk of Cumulative Effects on Benthic Habitats | Physical risk on the marine benthic habitats | D6 (indirect) | 2005-2018 |
| Condition (function) | Eutrophication | Nitrate, phosphate, chlorophyll-a, turbidity, dioxygen | D5C1, D5C2, D5C4, D5C5 | 2010-2016 |
| Condition (function) | Non-indigenous species | | | 2012-2017 |
| Condition (capacity) | Fish stock | Fishing mortality (F), biomass (SSB) | D3C1, D3C2 | 200 2006, 2012, 2018 |



Regarding the heritage category, objectives of the D1 of the MSFD are the starting point. Possible indicators that are included in the condition account include Protected habitats (surface) and species (abundance), including marine mammals, sharks and rays, seabirds, turtles, fish and cephalopods, based on Natura 2000 and other legislations (Endangered Species laws, OSPAR, Habitat Directive); IUCN red list index for marine species;

Regarding the capacity category, a readily available spatialized indicator that can be mapped is the maximum sustainable yield associated with the good ecological status of fish stocks.

Regarding the functionality category, indicators of conditions describing the functionality of the habitats include anthropogenic cumulative pressures on the marine environment (including benthic and pelagic areas) based on maps of habitats (extent), the degree of habitats sensitivity (matrices provided by the MNHN), the habitats exposure to cumulative/concomitante pressures including:

- Physical (dredging, concrete building of the coastline, trawling,... 12 pressures included in CarpeDiem),
- Chemical (contaminants),
- Eutrophication
- Marine litter
- Harvesting

### Technical choices

In these experimental accounts, we will produce condition accounts for the following subset of dimensions of interest.

In the heritage dimension :

- Bird populations (D1)

In the capacity dimension :

- Fishing stocks (D3)

In the functionality dimension :

- Eutrophication (D5)
- Invasive species (D2)
- Sea floor integrity (D6)

On each of these dimensions, the account will be built on a single accounting unit (a façade maritime) which may change from one dimension to another.

# 4.2 Illustrative accounts of ecosystem condition

In this subsection, we present an illustrative marine ecosystem condition account for each category of ecosystem condition and for the dimensions of interest retained in the context of this experiment. For each of them, we climb up the pyramid presented in figure 1. In the first paragraph, we start with a discussion of relevant raw datasets and how condition accounts could systematically be derived from them through specific conventions and norms. In the following paragraph, we present illustrative condition accounts. We finally discuss how specific indicators and figures[21] could be derived from such a set of condition accounts in a last paragraph.

## 4.2.1 Condition accounts for heritage concerns

The heritage dimension of ecosystem conditions lies in the conservation status of specific elements, considered at different levels (species, population level, individual level) depending on underlying values (e.g. levels at which dolphins are considered currently differ from anchovies as revealed by existing targets). In the MSFD, conservation targets are mostly covered by the first descriptor (biodiversity). Due to limited time and resources for experimentation, we focus the effort on specific dimensions of birds and marine mammals conservation status.

### Technical choices

In these experimental accounts, most dimensions of interest related to the heritage dimension are related to descriptor 1.

In a full-fledged account, a monitoring would require a detailed monitoring of species populations.

### 4.2.1.1. Underlying data

In this experiment data used are the generic sources presented in section 4.2.2. The Wise marine information system for Europe proposes a Marine species and habitat dashboard that summarises known status, trends and distributions over two reporting periods: 2008-2012 and 2013-2018) based on the information reported by EU Member States[22].

### 4.2.1.2. Accounting tables

A few indicators can only be observed in map format such as density. Its aggregation would not be of much interest on a scale as large as the marine sub-regions and even less so in the global area. However, it was ideal for finding a prediction of abundance in the study area.

21 We can remind that ecosystem condition accounts provide all relevant information to derive meaningful indicators but they are not the indicators as discussed in section 2.

22 The conservation status, trends and distribution of the habitats referred to in Annex I and the species in Annex II, IV and V, under Article 17 of the Habitats Directive (92/43/EEC) and the population size, trends and distribution of the bird species in their territories under Article 12 of the Birds Directive (2009/147/EC).



**Table 4.2.3.2 : Illustrative condition accounts in the overall accounting unit "French metropolitan EEZ" for heritage dimensions.**

| | Dimension of interest[23] | | Variable values | | Reference level values | | Corresponding MSFD tag | | |
|---|---|---|---|---|---|---|---|---|---|
| Habitat covered (EUNIS niveau 2) | Name | Indicator (code) | Opening Value (2012) | Closing Value (2018) | Opening Value (2012) | Closing Value (2018) | Opening Value (2012) | Closing Value (2018) | Change in indicator |
| A7 | Strandings | (D01-..., proxy 1) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| A7 | Percentage of threatened marine mammals | (DXX) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| A7 | Richesse spécifique (oiseaux) | Nombre de groupes d'espèces (oiseaux) (?) | 13 | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| A7 | Richesse spécifique (mammifères) | Nombre de groupes d'espèces (mammifères) (?) | 5 | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| A7 | Abondance des oiseaux marins | | | | | | | | |
| A7 | Abondance des mammifères marins | | | | | | | | |

20 Ideally with reference to the dimensions identified in the table available at this link.

| Comptes de condition | ZEE | | | Code EUNIS de niveau 2 | |
|---|---|---|---|---|---|
| Dimensions | Indicateur de condition | | | A7 | Unité |
| Patrimoine | Nombre de groupe d'espèces (Richesse spécifique) | Oiseaux | | | |
| | | Année | hiver - 2011 | 13 | nb |
| | | | été - 2012 | 13 | |
| | | Mammifères marins | | | |
| | | Année | hiver - 2011 | 5 | nb |
| | | | été - 2012 | 5 | |

Figure 12 : Number of species groups in marine mammals and birds in the water column, A7 of the EUNIS Code

| Comptes de condition | ZEE | | | | | Code EUNIS de niveau 2 | |
|---|---|---|---|---|---|---|---|
| Dimensions | Indicateur de condition | | | | | A7 | Unité |
| Patrimoine | Abondance (Prédiction) | Oiseaux | | Groupe d'espèces | Nom des espèces en latins | | nb |
| | | Année | hiver - 2011 | alcides | fratercula arctica / uria aalge / alca torda | 76071 | |
| | | | | cormorans | phalacrocorax carbo / phalacrocorax aristotelis | 304 | |
| | | | | fou de bassan | morus bassanus | 58455 | |
| | | | | fulmar boreal | fulmarus glacialis | 5415 | |
| | | | | grand goeland gris | larus argentatus / larus michahellis | 3003 | |
| | | | | grand goeland noir | larus marinus / larus fuscus | 1489 | |
| | | | | grand labbe | stercorarius skua | 1604 | |
| | | | | macreuses | melanitta nigra / melanitta fusca | 4341 | |
| | | | | grands puffins | puffinus gravis / puffinus griseus / calonectris diomedea | Absence de données | |
| | | | | mouette tridactyle | rissa tridactyla | 23710 | |
| | | | | mouettes | chroicocephalus ridibundus / ichthyaetus melanocephalus | 8694 | |
| | | | | oceanites | hydrobates pelagicus / oceanodroma leucorhoa / oceanodroma castro | Absence de données | |
| | | | | petits puffins | puffinus puffinus / puffinus yelkouan / puffinus mauretanicus | 4832 | |
| | | | | plongeons | gavia stellata / gavia arctica / gavia immer | 538 | |
| | | | | sterne | sterna paradisaea / sterna hirundo / sternula albifrons / thalasseus sandvicensis | 363 | |
| | | | été - 2012 | alcides | fratercula arctica / uria aalge / alca torda | 2699 | |
| | | | | cormorans | phalacrocorax carbo / phalacrocorax aristotelis | 332 | |
| | | | | fou de bassan | morus bassanus | 32264 | |
| | | | | fulmar boreal | fulmarus glacialis | 2950 | |
| | | | | grand goeland gris | larus argentatus / larus michahellis | 6317 | |
| | | | | grand goeland noir | larus marinus / larus fuscus | 1163 | |
| | | | | grand labbe | stercorarius skua | 614 | |
| | | | | macreuses | melanitta nigra / melanitta fusca | Absence de données | |
| | | | | grands puffins | puffinus gravis / puffinus griseus / calonectris diomedea | 16694 | |
| | | | | mouette tridactyle | rissa tridactyla | 573 | |
| | | | | mouettes | chroicocephalus ridibundus / ichthyaetus melanocephalus | 593 | |
| | | | | oceanites | hydrobates pelagicus / oceanodroma leucorhoa / oceanodroma castro | 8650 | |
| | | | | petits puffins | puffinus puffinus / puffinus yelkouan / puffinus mauretanicus | 7520 | |
| | | | | plongeons | gavia stellata / gavia arctica / gavia immer | Absence de données | |
| | | | | sterne | sterna paradisaea / sterna hirundo / sternula albifrons / thalasseus sandvicensis | 1606 | |

Figure 13.a. Seasonal distribution of abundance of groups of bird species in the exclusive economic zone



| Comptes de condition | ZEE | | | | | Code EUNIS de niveau 2 | |
|---|---|---|---|---|---|---|---|
| Dimensions | Indicateur de condition | | | | | A7 | Unité |
| Patrimoine | Abondance (Prédiction) | Mammifères marins | | Groupe d'espèces | Nom des espèces en latins | | nb |
| | | Année | hiver - 2011 | Dauphin | Delphinus delphis / Stenella coeruleoalba | 211529 | |
| | | | | globicéphalinés | Globicephala melas / Grampus griseus | 3527 | |
| | | | | Grand dauphin | Tursiops truncatus | 7578 | |
| | | | | Marsouin | Phocoena phocoena | 1497 | |
| | | | | Rorqual | Balaenoptera physalus | 233 | |
| | | | été - 2012 | Dauphin | Delphinus delphis / Stenella coeruleoalba | 211529 | |
| | | | | globicéphalinés | Globicephala melas / Grampus griseus | 2844 | |
| | | | | Grand dauphin | Tursiops truncatus | 6815 | |
| | | | | Marsouin | Phocoena phocoena | 2972 | |
| | | | | Rorqual | Balaenoptera physalus | 804 | |

Figure 13.b. Seasonal distribution of abundance of groups of marine mammal species in the exclusive economic zone

| Comptes de condition | ZEE | | | | | Code EUNIS de niveau 2 | | |
|---|---|---|---|---|---|---|---|---|
| Dimensions | Indicateur de condition | | | | | A7 | | Unité |
| Patrimoine | Classification IUCN | Oiseaux | | | Statut fr | Atlantique | Méditerranée | % |
| | | Année | hiver - 2011 | Pourcentage de groupe d'espèces se situant dans cette classe | EX : 1 | 0 | 0 | |
| | | | | | EW : 2 | 0 | 0 | |
| | | | | | RE : 3 | 0 | 0 | |
| | | | | | CR : 4 | 15,38 | 7,69 | |
| | | | | | EN : 5 | 0 | 7,69 | |
| | | | | | VU : 6 | 7,69 | 0 | |
| | | | | | NT : 7 | 30,77 | 15,38 | |
| | | | | | LC : 8 | 15,38 | 0 | |
| | | | | | DD : 9 | 7,69 | 0 | |
| | | | | | NA : 10 | 15,38 | 0 | |
| | | | été - 2012 | Pourcentage de groupe d'espèces se situant dans cette classe | EX : 1 | 0 | 0 | |
| | | | | | EW : 2 | 0 | 0 | |
| | | | | | RE : 3 | 0 | 0 | |
| | | | | | CR : 4 | 15,38 | 7,69 | |
| | | | | | EN : 5 | 7,69 | 7,69 | |
| | | | | | VU : 6 | 23,08 | 15,38 | |
| | | | | | NT : 7 | 30,77 | 15,38 | |
| | | | | | LC : 8 | 15,38 | 0 | |
| | | | | | DD : 9 | 0 | 0 | |
| | | | | | NA : 10 | 7,69 | 0 | |

Figure 15 : Seasonal distribution of the percentage of bird species groups according to the IUCN classification in the EEZ

| Comptes de condition | ZEE | | | | | Code EUNIS de niveau 2 | | |
|---|---|---|---|---|---|---|---|---|
| Dimensions | Indicateur de condition | | | | | A7 | | Unité |
| | | Mammifères marins | | | Statut fr | Atlantique | Méditerranée | |
| Patrimoine | Classification IUCN | Année | hiver - 2011 | Pourcentage de groupe d'espèces se situant dans cette classe | EX : 1 | 0 | 0 | % |
| | | | | | EW : 2 | 0 | 0 | |
| | | | | | RE : 3 | 0 | 0 | |
| | | | | | CR : 4 | 0 | 0 | |
| | | | | | EN : 5 | 0 | 0 | |
| | | | | | VU : 6 | 0 | 20 | |
| | | | | | NT : 7 | 40 | 40 | |
| | | | | | LC : 8 | 40 | 20 | |
| | | | | | DD : 9 | 0 | 0 | |
| | | | | | NA : 10 | 0 | 0 | |
| | | | été - 2012 | Pourcentage de groupe d'espèces se situant dans cette classe | EX : 1 | 0 | 0 | |
| | | | | | EW : 2 | 0 | 0 | |
| | | | | | RE : 3 | 0 | 0 | |
| | | | | | CR : 4 | 0 | 0 | |
| | | | | | EN : 5 | 0 | 0 | |
| | | | | | VU : 6 | 0 | 20 | |
| | | | | | NT : 7 | 40 | 40 | |
| | | | | | LC : 8 | 40 | 20 | |
| | | | | | DD : 9 | 0 | 0 | |
| | | | | | NA : 10 | 0 | 0 | |

**Figure 16. Seasonal distribution of the percentage of marine mammal species groups according to the IUCN classification in the EEZ**

| Comptes de condition | ZEE | | | | Code EUNIS de niveau 2 | |
|---|---|---|---|---|---|---|
| Dimensions | Indicateur de condition | | | | A7 | Unité |
| Patrimoine | Zones de protections des espèces et de la faunes marines | Zones de protection spéciale | | | 33545,55 | km² |
| | | Sites d'importance communautaire | | | 24500,014 | km² |
| | | Parcs naturels Marins | | | 23851,027 | km² |
| | Echouage | Année | Nombre d'individus échoués parmis les mamifères marins | 2014 | 1115 | nb |
| | | | | 2015 | 734 | |
| | | | | 2016 | 1402 | |
| | | | | 2017 | 1620 | |
| | | | | 2018 | 1528 | |

**Figure 17. Visualization of indicators of the condition of protected area surfaces and the number of strandings**



## 4.2.1.3. Derived figures, maps and indicators

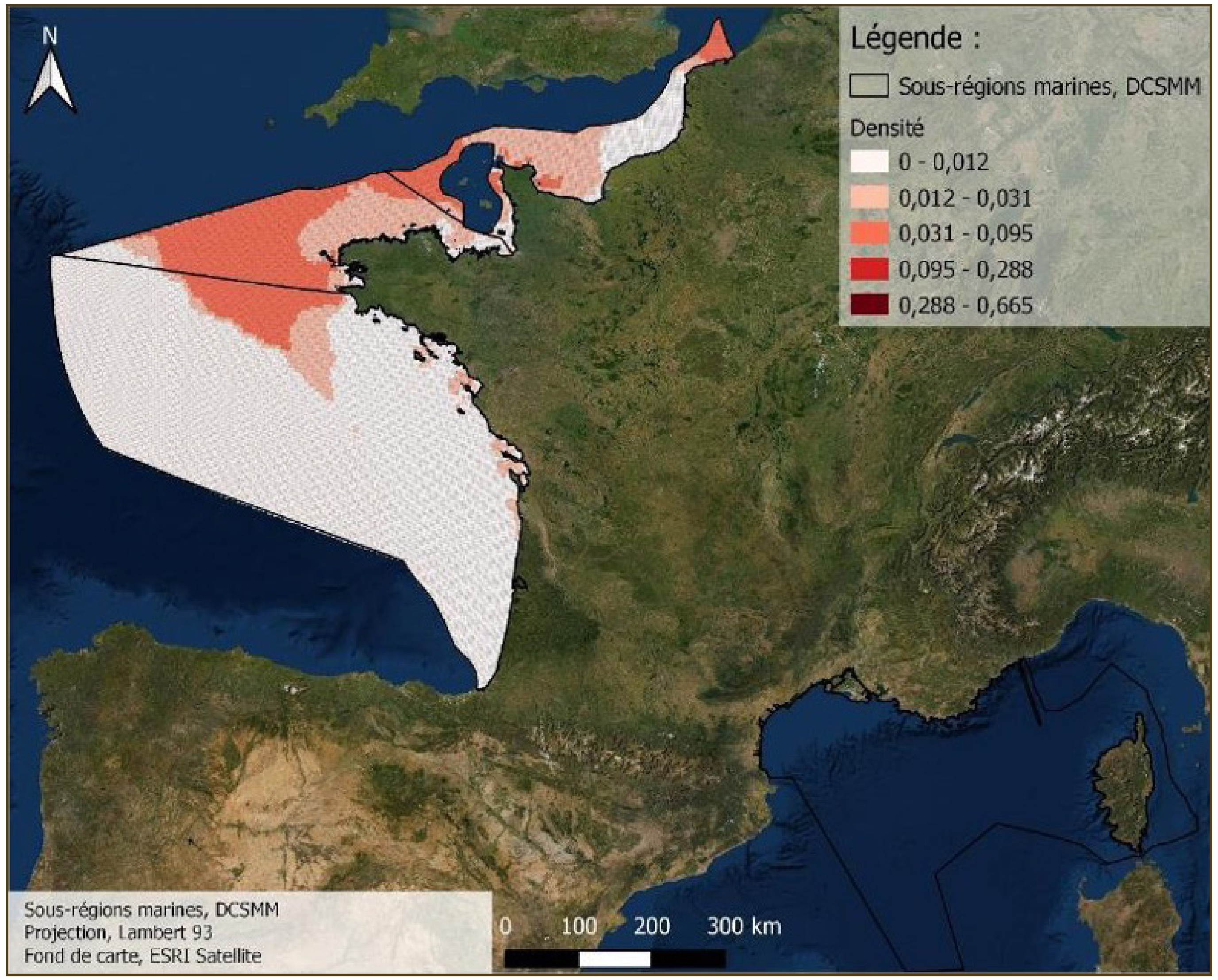



**Figure 10 : Visualization of density prediction for porpoises (marsouins)**

Good ecological status and have therefore been added to the condition account results. Estimations of abundance (figure 13.a and 13.b) are calculated from aerial observations (SAMM 1 : observations ran in 2011-2012 and the report was published in 2014). Concerning abundance of birds, observations are organised in different zones : cost, ocean shelf, open sea. Abundance is effectively estimated according to the ocean shelf and open sea observations, that often reflect the real abundance. However, the estimation calculus does not reflect the real abundance of cormorants that mainly live near cost. That implies that cormorants' abundance is under-estimated with this method.

MSFD targets concerning abundance of species : no-net loss of biodiversity, and in the short term, no reduction of the abundance of studied and estimated species. That means that the objective is dynamic. Thus, we will be able to assess the good ecological state or not on the heritage dimension as soon as the results of the second french aerial monitoring of marine megafauna will be published : winter observations have been carried out in 2021, the program is still running and the last observations will be done by summer 2022. In addition to this, the laboratory is working on a harmonisation between the two monitoring cycles in order to allow the comparison between 2011-2012 and 2021-2022.

Estimations of abundance presented above were calculated from a cartographic method developed in Annex D, from density and number of observations. Estimations of abundance have been also carried out by the Pelagis laboratory itsel (Pettex et al., 2014), considering parameters specific for each species.Our estimations and Pelagis's ones must be compared.The difference of method explains the differences between estimated abundance, that are more or less significant depending on the species. The publication of the results of SAMM

2 will add to the estimations some cartographic projections of density (that were not directly produced in SAMM 1) that could be used in our cartographic framework.

Concerning bird abundance in land ecosystems, several European countries or regions (in France or in Scotland for instance) collect the data with observations run by volunteers (birdwatchers) during observation campaigns. The data is then collected in a bottom-up approach with the contribution of associations (LPO in France[24], several associations in Scotland[25]). On the contrary, this volunteering-based observation is not possible for marine ecosystems that are less occupied by humanity. Then the main source of data for marine birds consists in aerial observations run every ten years by the Pelagis laboratory. Thus, the monitoring cost to survey bird populations is higher for marine ecosystems than for the land ones, and the accounting is easier for land ecosystems.

24 https://www.lpo.fr/decouvrir-la-nature/loisirs-nature/agenda-nature/agenda-lpo-france/2022/comptage-national-oiseaux-des-jardins2

25 https://www.environment.gov.scot/our-environment/state-of-the-environment/ecosystem-health-indicators/condition-indicators/indicator-5-species-diversity-bird-populations/



## 4.2 Illustrative accounts of ecosystem condition

Eight out of the eleven descriptors of good ecological status are related to the functionality of marine ecosystem conditions. Due to limited time and resources for experimentation, we focus the effort on descriptor 6 in this experiment.

### Technical choices

In these experimental accounts, we focus on descriptors 2 (invasive species), 5 (eutrophication) and 6 (sea-floor integrity).

In a full-fledged account, a database could organise a monitoring of the main pressure subject to a need for monitoring.

### 4.2.2.1. Underlying data

For invasive species, the 2018 MSFD assessment of 2018 collected the first observations from 2012 to 2017. The next evaluation will be published in 2024, collecting the observations from 2018 to 2023.

The related environmental target consists in the reduction of this indicator from one period to the next. Thus, reference levels shall be the value of the previous period and GES will only be assessed with the reporting of the next MSFD cycle starting in 2024.

For eutrophication, the good ecological status of marine waters is assessed from the monitoring of 6 dimensions reflecting intensive properties of marine ecosystems. These are the raw data that shall constitute condition accounts :

- D5-C1-ind1: nutrient concentration in the water column;
- D5-C2-ind1: chlorophyll-a concentration in the water column;
- (D5C3-ind1: harmful algal blooms);
- D5C4-ind1: turbidity of the water column;
- D5C5-ind1: bottom oxygen concentration;
- D5C7-ind1: state of macrophyte communities in benthic habitats (hard substrate perennial macroalgae in the subtidal zone, hard substrate perennial macroalgae in the mid-littoral intertidal zone, macroalgae of the upper mid- and sub-littoral stages, Posidonia meadows and grass beds);
- D5C8-ind1: status of macrofaunal communities in benthic habitats.

According to the Wise marine information system for Europe, 10 databases have been used to assess these dimensions of GES in France for the 2nd cycle. Results are summarised for all maritime façades in Devecker and Lefèvre (2018). Some of the raw data can be recovered from the generic sources presented in section 4.2.2.

The way data could be organised at the level of the BSU in the integrated dataset is twofold. In one option, the BSU would simply point at the relevant raw dataset(s) that informs on the values of these variables within the water bodies covering the BSU. As this may prove complicated, an alternative may be to reprocess the information from the raw data to attribute an estimated average value over the area covered by the BSU. Although more simple in appearance, this option comes with a degradation of existing data which may reduce data accuracy for later treatment, especially if data are to be recombined to derive average values at the scale of water bodies. The best option would depend on the extent of such degradation (which depends on BSU scale, spatial variability of the variable of interest and consistency with the grid used to define elementary geographical units of assessment for descriptor 5). This would deserve further analyses.

## 4.2.2.2. Accounting tables

Accounting tables related to these functionality dimensions of marine ecosystem condition are presented below.

**Table 4.2.3.2 : Illustrative condition accounts for eutrophication and invasive species in the accounting unit "Mer Celtique" .**

| Category | Dimension of interest[27] | | Variable values | | Reference level values | | Corresponding MSFD tag | | |
|---|---|---|---|---|---|---|---|---|---|
| | Name | Indicator (code) | Opening Value (2012) | Closing Value (2018) | Opening Value (2012) | Closing Value (2018) | Opening Value (2012) | Closing Value (2018) | Change in indicator |
| Functio -nality | Trends in new introductions of non-native species | Number of non-indigenous species newly observed since previous assessment (D02-C1-ind1) | n.d. | 20 | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Nutrient concentration in the water column (nitrogen, coastal waters) | Percentage area of units proved in GES (D5-C1-ind1_N_coastal) | n.d. | 20 | n.d. | See box 4.2.2.3-1 | n.d. | 98,8 | n.d. |
| | Nutrient concentration in the water column (phosphorus, coastal waters) | Percentage area of units proved in GES (D5-C1-ind1_P_coastal) | n.d. | 0 | | | | | |
| | Nutrient concentration in the water column (nitrogen, intermediate and offshore waters) | Percentage area of units proved in GES (D5-C1-ind1_N_intermediate+offshore) | n.d. | 88,8 | | | | | |
| | Nutrient concentration in the water column (phosphorus, intermediate and offshore waters) | Percentage area of units proved in GES (D5-C1-ind1_P_intermediate+offshore) | n.d. | 88,8 | | | | | |
| | Chlorophyll-a concentration in the water column | Percentage area of units proved in GES (D5-C2-ind1) | n.d. | 92.9 | | | | | |
| | Harmful algal blooms | Threshold undefined at the level of units | n.d. | n.d. | | | | | |
| | Turbidity of the water column | Percentage area of units proved in GES (D5C4-ind1) | n.d. | 95,9 | | | | | |

27 Ideally with reference to the dimensions identified in the table available at this link.



| Category | Name | Indicator (code) | Opening Value (2012) | Closing Value (2018) | Opening Value (2012) | Closing Value (2018) | Opening Value (2012) | Closing Value (2018) | Change in indicator |
|---|---|---|---|---|---|---|---|---|---|
| Functio -nality | Bottom oxygen concentration | Percentage area of units proved in GES (D5C5-ind1) | n.d. | 82,6 | n.d. | See box 4.2.2.3-1 | n.d. | 98,8 | n.d. |
| | State of macrophyte communities in benthic habitats[28] (coastal areas) | Percentage area of units proved in GES (D5C7-ind1) | n.d. | 64 | | | | | |
| | State of macrofaunal communities in benthic habitats | Percentage area of units proved in GES (D5C8-ind1) | n.d. | 92.9 | | | | | |
| | Risks of Cumulative Effects in Metropolitan France | (D06 XXX) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |

## 4.2.2.3. Derived figures, maps or indicators

We shall first discuss how condition condition accounts could be aggregated to build specific indicators for each descriptor and then discuss the relevance of specific integrated représentations.

**Aggregate indicators for non-indigenous species**

Given the absence of trends and a unique dimension, aggregate insights regarding this issue are currently limited to a comparison between geographic areas regarding this issue.

| Marine subregion | North sea | Celtic seas | Bay of Biscay | Mediterranean sea |
|---|---|---|---|---|
| Number of Non indigenous species newly observed between 2012 and 2017 | 15 | 20 | 39 | 16 |

**Table 8. Newly observed NIS by marine subregions between 2012 and 2017**

28 hard substrate perennial macroalgae in the subtidal zone, hard substrate perennial macroalgae in the mid-littoral intertidal zone, macroalgae of the upper mid- and sub-littoral stages, Posidonia meadows and grass beds.

**Aggregate indicators for eutrophication**

Also relying on multiple indicators, eutrophication may be a relatively simple case as explicit rules and conventions exist regarding how these results shall be aggregated to reflect overall good ecological status on this dimension (See box 4.2.2.3-1).

For this dimension a relevant aggregated indicator shall be chosen consistently with the recommended aggregated indicator at the descriptor level, for the the marine sub-region considered: an estimate of the area not subject to eutrophication in square kilometres (km², see Figure 11) or in proportion (percentage). As defined in box 4.2.2.3-1, the aggregation rule could not directly be implemented from the accounts but would require combining data from the integrated dataset.

As in these figures, such an assessment could further distinguish coastal, intermediate and offshore waters both in accounts and in the assessment due to the significant differences in eutrophication in these areas.

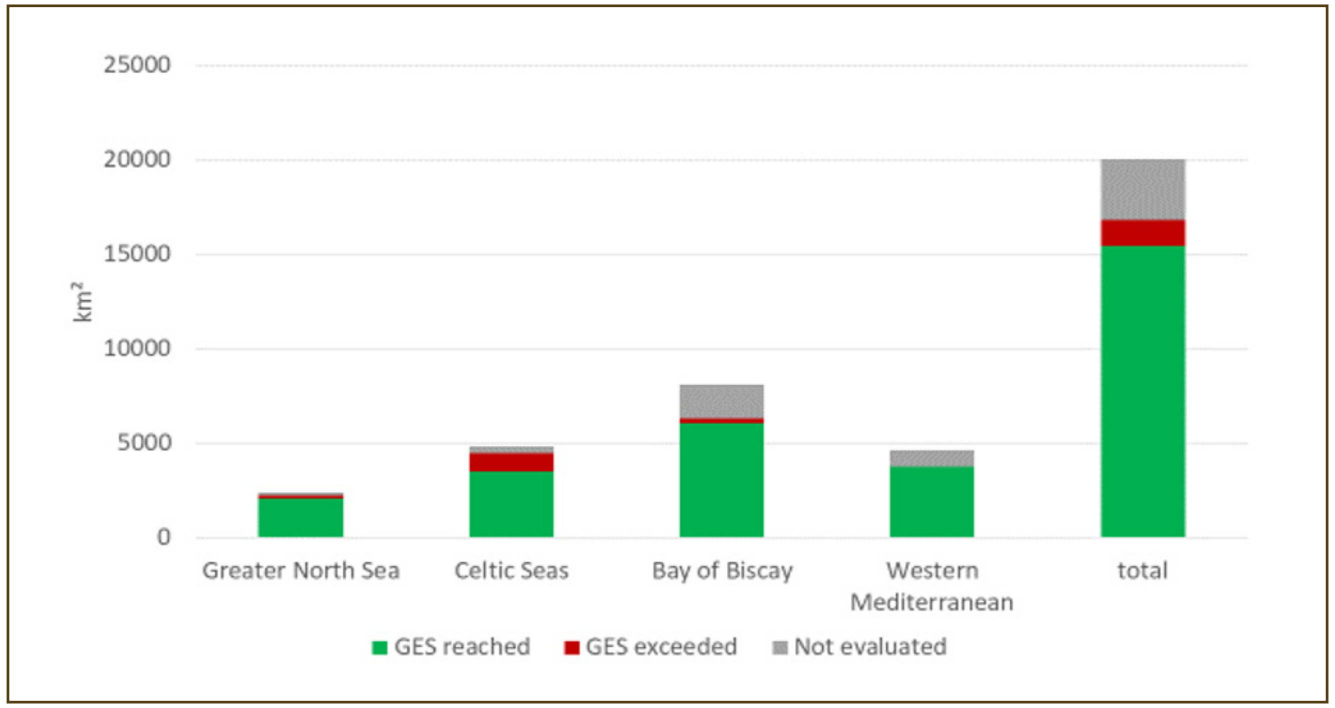



Figure 11. aggregated assessment of the good ecological status of coastal water masses for eutrophication for the period 2010 - 2016.



## Box 4.2.2.3-1
## Aggregation rules for the assessment of GES regarding eutrophication

(source : arrêté du 9 septembre 2019 relatif à la définition du bon état écologique des eaux marines et aux normes méthodologiques d'évaluation)

Eutrophication can be defined at different levels of aggregation as evidenced by these rules defined in France in a 2019 order.

"**The elementary geographical unit of assessment** for descriptor 5 corresponds :
- in coastal waters, to the coastal water bodies as defined in the aforementioned modified order of 12 January 2010,
- in intermediate waters, to a square grid of 1:20° sides,
- in offshore waters, to a square grid of 1/5° sides.

[...]

The degree of achievement of good ecological status is expressed as follows:
**(a) for each criterion :**
- values obtained for each elementary geographical unit of assessment ;
- (a) for each criterion: values achieved for each elementary geographical unit of assessment; at the scale of the coastal, intermediate and offshore waters respectively of the marine sub-region, an estimate of the extent to which the threshold values have been achieved;

**(b) at the descriptor level, for each elementary geographical unit of assessment,** integrating the assessment results of the criteria:
- a score of zero is assigned to criteria meeting the characteristics of good ecological status;
- criteria D5C3, D5C4, D5C7, D5C8 are scored as one if they do not meet the criteria for good ecological status;
- D5C1, D5C2 and D5C5 are scored as two if they do not meet the criteria for good ecological status;

The geographical unit of assessment is subject to eutrophication, if :
- in coastal waters, the sum of the scores for all criteria is greater than or equal to 5 or if criterion D5C6 does not meet the characteristics of good ecological status;
- in intermediate and offshore waters, the sum of the scores for all criteria is greater than or equal to 3;

**(c) at the descriptor level, for the coastal, intermediate and offshore waters respectively of the marine sub-region considered**
- (c) at the descriptor level, for coastal, intermediate and offshore waters respectively of the marine sub-region under consideration: estimate of the area not subject to eutrophication in square kilometres (km2 ) or proportion (percentage)."

**Aggregate indicators for sea-floor integrity**

Physical risk on the marine benthic habitats is mapped for all the areas that include anthropogenic cumulative pressures (Figure 12). This indicator is calculated based on 1) the extent of marine habitats, 2) the map of physical pressures that impact the marine environment, which include 21 human activities (e.g. dredging, concrete building of the coastline, trawling) and 12 physical pressures 3) the degree of habitats sensitivity to the different physical pressures using matrices provided by the Natural History Museum (Quemmerais-Amice et al., 2020). Then, the risks of cumulative effect make it possible to observe the high-risk areas according to habitats by the accumulation of pressures there (Figure 13).

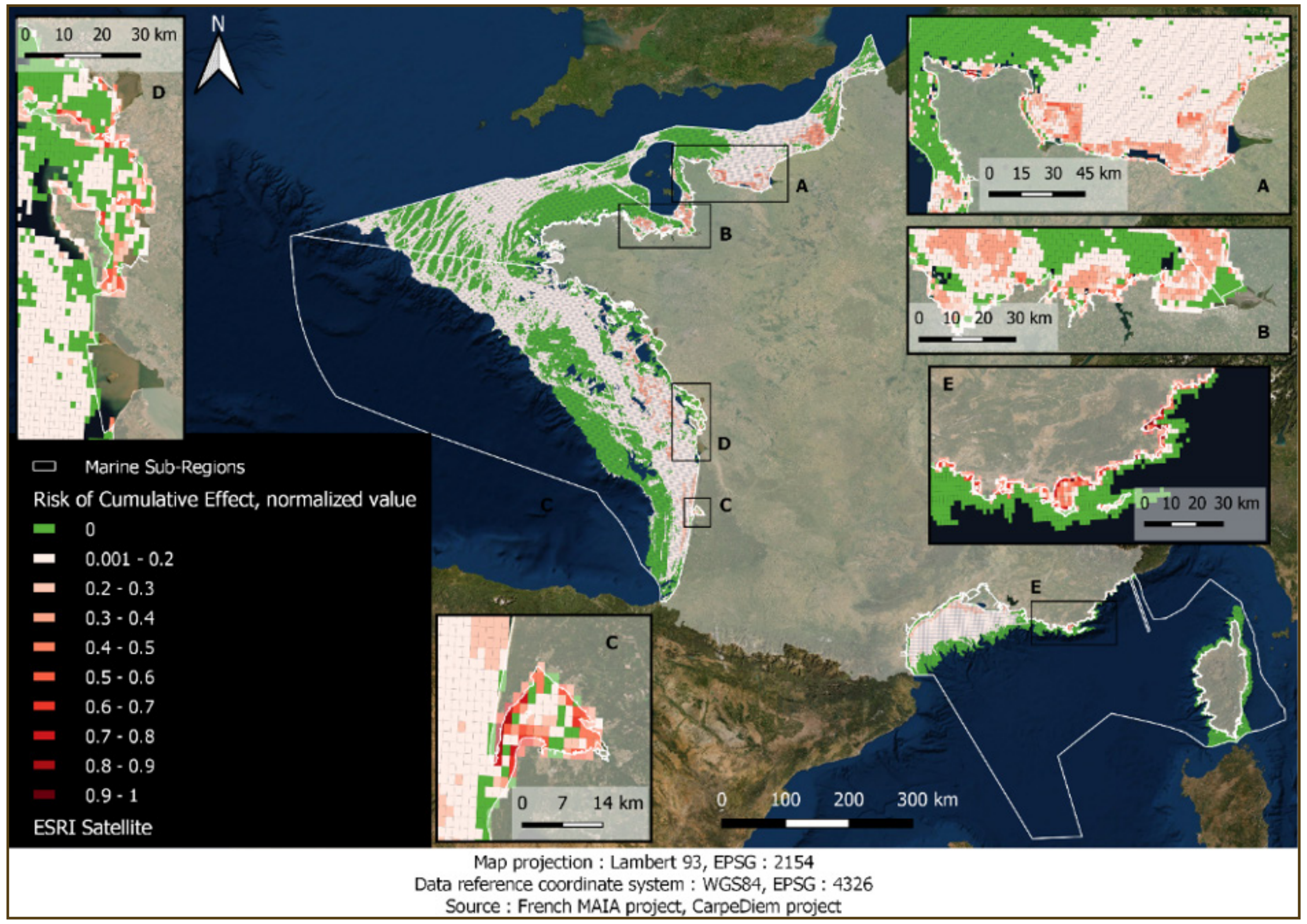



**Figure 12 : Distribution of Risks of Cumulative Effects in Metropolitan France**

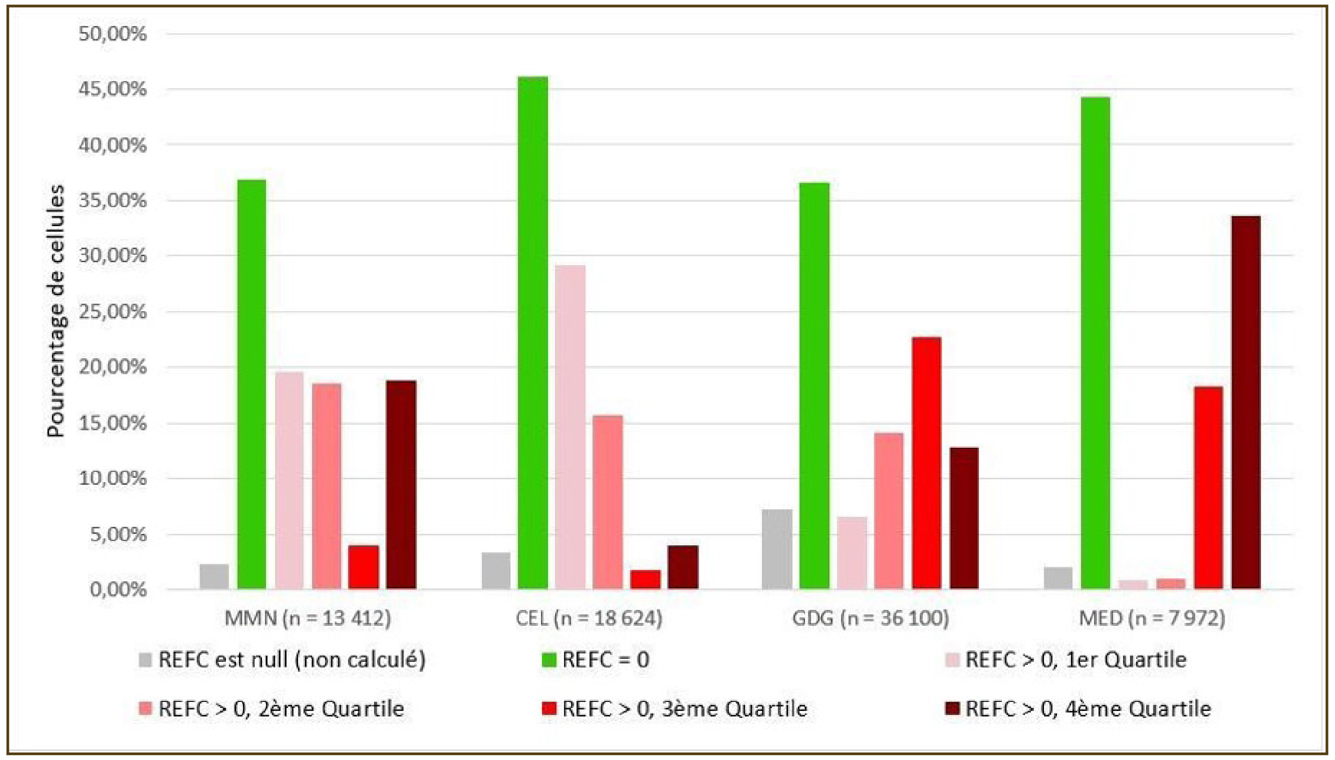



**Figure 13. Distribution of concomitant risk values per quartile and per marine sub-regions of the MSFD in Metropolitan France**



**Integrated representations for risks over ecosystem functionality**

Risks of different nature are difficult to compare. This calls for disaggregate representations of planetary boundary types on a subset of risks identified at the scale of the accounting unit. Such representations have proven to be particularly communicating and can be found at global scale (Steffen et al, 2015), but also at lower scales such as in the EFESE program (CGDD, 2020, figure 6 p. 36). This later example suggests that such representations do not require a single indicator with a definite threshold to be defined, but that they could instead be derived from a well-defined qualitative scale.

If an integrated indicator were to be produced, a meaningful way to integrate different dimensions can be a one-out-all-out integration rule[29]. The resulting indicator could straightforwardly be interpreted as answering the question "Are all significant risks to the overall functionality of the ecosystem adequately managed?".

## 4.2.3 Condition accounts for capacity concerns

The capacity dimension of ecosystem conditions mainly lies in the two following descriptors : fish stocks (D3) and contaminants (D9). Due to limited time and resources for experimentation, we focus the effort on descriptor 3.

### Technical choices

In these experimental accounts, we focus on descriptor 3. We present the state of fishing stocks officially associated with GES[30] in each submarine region in 2012 and 2018.

We then complement the data used by assessments carried in other frameworks.

In a full-fledged account, a database could be organised by fishing stocks. Each cell of the grid of the integrated spatial database would point to the stocks that cover it.

This way, accounting tables for fishing stocks could be recovered for each submarine region by recovering the information for all stocks covered by some cells of the region.

### 4.2.3.1. Underlying data

In a full-fledged account, a database could be organised by fishing stocks as assessed by the International Council for the Exploration of the Sea (ICES) and completed by other sources. Between 2000 and 2018, this organisation assessed 40 species representing 104 to 115 stocks. We can note that the availability of the data from the ICES for the Mediterranean sea is limited. In MSFD reporting, the Mediterranean sea is as well less detailed on this dimension.

In this experiment, we focus on the "Mer Celtique" façade maritime (the accounting unit). We first review the assessment carried out in the 2nd cycle of the MSFD for each of the 48 stocks explicitly identified for this area in the 2019 order defining good ecological status of marine ecosystems. We then reviewed the data of the ICES concerning the stocks to complete missing information.

Regarding the rules and conventions relating data and accounting tables, each cell of the grid of the integrated spatial database would point to the stocks that cover it. This way, accounting tables for fishing stocks could be recovered for each submarine region by recovering the information for all stocks covered by some cells of the region.

29 Taking the gradation of objects, such a rule attributes the worst gradation over the set of objects considered.

30 According to table 2 of the Arrêté du 9 septembre 2019 relatif à la définition du bon état écologique des eaux marines et aux normes méthodologiques d'évaluation.

## 4.2.3.2. Accounting tables

Accounting tables related to these utilitarian dimensions of marine ecosystem condition are presented below.

**Table 4.2.3.2 : Illustrative condition accounts for fishing stocks in the accounting unit "Mer Celtique".**

| Dimension of interest (category) | Dimension of interest[31] | | Variable values | | Reference level values | | Corresponding MSFD tag | | |
|---|---|---|---|---|---|---|---|---|---|
| | Name | Indicator (code) | Opening Value (2012) | Closing Value (2018) | MSY (2012) | MSY (2018) | Opening Value (2012) | Closing Value (2018) | Change in indicator |
| Capacity | Anguilla anguilla (Anguille d'Europe) from the area: Atlantique Nord et Méditerranée | Fishing mortality (D1-C1-ind1_2) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Capros aper (Sanglier) from the area: Zones CIEM VI, VII, VIII | Fishing mortality (D1-C1-ind1_7) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Dicentrarchus labrax (Bar européen) from the area: Zones CIEM IVbc, VIIa, VIId-h | Fishing mortality (D1-C1-ind1_12) | n.d. | n.d. | n.d. | n.d. | BEE not achieved | BEE not achieved | = |
| | Gadus morhua (Morue d'Atlantique) from the area: Zone CIEM VIIe-k | Fishing mortality (D1-C1-ind1_16) | n.d. | n.d. | n.d. | n.d. | BEE not achieved | BEE not achieved | = |
| | Lepidorhombus whiffiagonis (Cardine franche) from the area: Zones CIEM VIIbk, VIIIabd | Fishing mortality (D1-C1-ind1_19) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Lophius budegassa (Baudroie rousse) from the area: Zones CIEM VIIb-k, VIIIabd | Fishing mortality (D1-C1-ind1_27) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Lophius piscatorius (Baudroie commune) from the area: Zones CIEM VIIb-k, VIIIabd | Fishing mortality (D1-C1-ind1_28) | n.d. | n.d. | n.d. | n.d. | BEE not achieved | BEE achieved | + |
| | Melanogrammus aeglefinus (Eglefin) from the area: Zone CIEM VIIb-k | Fishing mortality (D1-C1-ind1_29) | n.d. | n.d. | n.d. | n.d. | BEE not achieved | BEE not achieved | = |

31 Ideally with reference to the dimensions identified in the table available at this link.



| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Capacity | Merlangius merlangus (Merlan) from the area: Zone CIEM VIIbce-k | Fishing mortality (D1-C1-ind1_31) | n.d. | n.d. | n.d. | n.d. | BEE achieved | BEE not achieved | - |
| | Merluccius merluccius (Merlu européen) from the area: Zones CIEM II, III, IV, V, VI, VII, VIIIabd | Fishing mortality (D1-C1-ind1_33) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Pleuronectes platessa (Plie d'Europe) from the area: Zone CIEM VIIe | Fishing mortality (D1-C1-ind1_55) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | = |
| | Pleuronectes platessa (Plie d'Europe) from the area: Zone CIEM VIIh-k | Fishing mortality (D1-C1-ind1_56) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | = |
| | Pollachius pollachius (Lieu jaune) from the area: Zones CIEM VI, VII | Fishing mortality (D1-C1-ind1_60) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Scophthalmus rhombus (Barbue) from the area: Zones CIEM IIIa, IV, VIIde | Fishing mortality (D1-C1-ind1_82) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Solea solea (Sole commune) from the area: Zone CIEM VIIe | Fishing mortality (D1-C1-ind1_91) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Solea solea (Sole commune) from the area: Zone CIEM VIIh-k | Fishing mortality (D1-C1-ind1_92) | n.d. | n.d. | n.d. | n.d. | BEE achieved | BEE achieved | = |
| | Micromesistius poutassou (Merlan bleu) from the area: Zones CIEM I-IX, XII, XIV | Fishing mortality (D1-C1-ind1_35) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Sardina pilchardus (Sardine commune) from the area: Zones CIEM VIIIabd, VII | Fishing mortality (D1-C1-ind1_78) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Scomber scombrus (Maquereau commun) from the area: Zones CIEM II, III, IV, VI, VII, VIII | Fishing mortality (D1-C1-ind1_80) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Capacity | Thunnus alalunga (Thon germon) from the area: Zones CICTA AL31-32 Atlantique Nord | Fishing mortality (D1-C1-ind1_95) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Thunnus thynnus (Thon rouge de l'Atlantique) from the area: Zones CICTA BF53-54-57-58-59-62-65-66 Atlantique Est et Méditerranée | Fishing mortality (D1-C1-ind1_97) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Trachurus trachurus (Chinchard d'Europe) from the area: Zones CIEM II, IV, V, VI, VII, VIIIabcde | Fishing mortality (D1-C1-ind1_98) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Xiphias gladius (Espadon) from the area: Zones CICTA BIL91-92-93-94A-94B-94C Atlantique Nord | Fishing mortality (D1-C1-ind1_100) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Aphanopus carbo (Sabre noir) from the area: Zones CIEM Vb, VI, VII, XIIb, VIII, IXa | Fishing mortality (D1-C1-ind1_3) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Brosme brosme (Brosme) from the area: Zones CIEM IIIa, Vb, VIa, XIIb, IV, VII, VIII, IX | Fishing mortality (D1-C1-ind1_5) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Coryphaenoides rupestris (Grenadier de roche) from the area: Zones CIEM Vb, VI, VII, XIIb | Fishing mortality (D1-C1-ind1_9) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Molva dypterygia (Lingue bleue) from the area: Zones CIEM Vb, VI, VII | Fishing mortality (D1-C1-ind1_37) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Molva molva (Lingue franche) from the area: Zones CIEM IIIa, IVa, VI, VII, VIII, IX, XIV | Fishing mortality (D1-C1-ind1_38) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Pagellus bogaraveo (Dorade rose) from the area: Zones CIEM VI, VII, VIII | Fishing mortality (D1-C1-ind1_48) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Phycis blennoides (Phycis de fond) from the area: Zones CIEM I-X, XII | Fishing mortality (D1-C1-ind1_52) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |



| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Capacity | Leucoraja naevus (Raie fleurie) from the area: Zones CIEM VI, VII, VIIIabd | Fishing mortality (D1-C1-ind1_21) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Mustelus spp. (Emissoles) from the area: Atlantique Nord-Est | Fishing mortality (D1-C1-ind1_41) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Prionace glauca (Requin peau bleue) from the area: Atlantique Nord | Fishing mortality (D1-C1-ind1_63) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Raja brachyura (Raie lisse) from the area: Zone CIEM VIIe | Fishing mortality (D1-C1-ind1_64) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Raja circularis (Raie circulaire) from the area: Zones CIEM VI, VII | Fishing mortality (D1-C1-ind1_66) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Raja clavata (Raie bouclée) from the area: Zone CIEM VIIe | Fishing mortality (D1-C1-ind1_67) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Raja microocellata (Raie mêlée) from the area: Zone CIEM VIIde | Fishing mortality (D1-C1-ind1_70) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Raja montagui (Raie douce) from the area: Zones CIEM VIIa.e-h | Fishing mortality (D1-C1-ind1_73) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Raja undulata (Raie brunette) from the area: Zone CIEM VIIde | Fishing mortality (D1-C1-ind1_74) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Scyliorhinus canicula (Petite roussette) from the area: Zones CIEM VI, VIIa-c.e-j | Fishing mortality (D1-C1-ind1_84) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Scyliorhinus stellaris (Grande roussette) from the area: Zones CIEM VI, VII | Fishing mortality (D1-C1-ind1_86) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Capacity | Squalus acanthias (Aiguillat commun) from the area: Atlantique Nord-Est | Fishing mortality (D1-C1-ind1_94) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Loligo forbesii (Encornet veiné) from the area: Zone CIEM VIIde | Fishing mortality (D1-C1-ind1_23) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Loligo vulgaris (Encornet) from the area: Zone CIEM VIIde | Fishing mortality (D1-C1-ind1_25) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Octopodidae (Pieuvres, poulpes) from the area: Zone CIEM VII | Fishing mortality (D1-C1-ind1_44) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Ommastrephidae (Calmars volants) from the area: Zones CIEM VIIa-e,gk | Fishing mortality (D1-C1-ind1_47) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Buccinum undatum (Buccin) from the area: Ouest Cotentin | Fishing mortality (D1-C1-ind1_6) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| | Pecten maximus (Coquille Saint-Jacques) from the area: Baie de Saint-Brieuc | Fishing mortality (D1-C1-ind1_50) | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |

**Comment: In a first approach, the fishing stocks considered are those listed in table 2 of the Arrêté du 9 septembre 2019 relatif à la définition du bon état écologique des eaux marines et aux normes méthodologiques d'évaluation.**

**Sources : ICES Stock Assessment Database. Copenhagen, Denmark. ICES. [accessed: 08/12/2022]. https://standardgraphs.ices.dk**



## 4.3.3.3. Derived figures, maps or indicators

The first systematic indicator which may be derived from such accounts is the headcount of stocks assessed and respecting MSY (Figure 14). This could lead to the type of representation as presented in figure 21 for the whole French metropolitan EEZ. Spatialized representations, naming the stocks concerned by unsustainable management practices, could also be proposed.

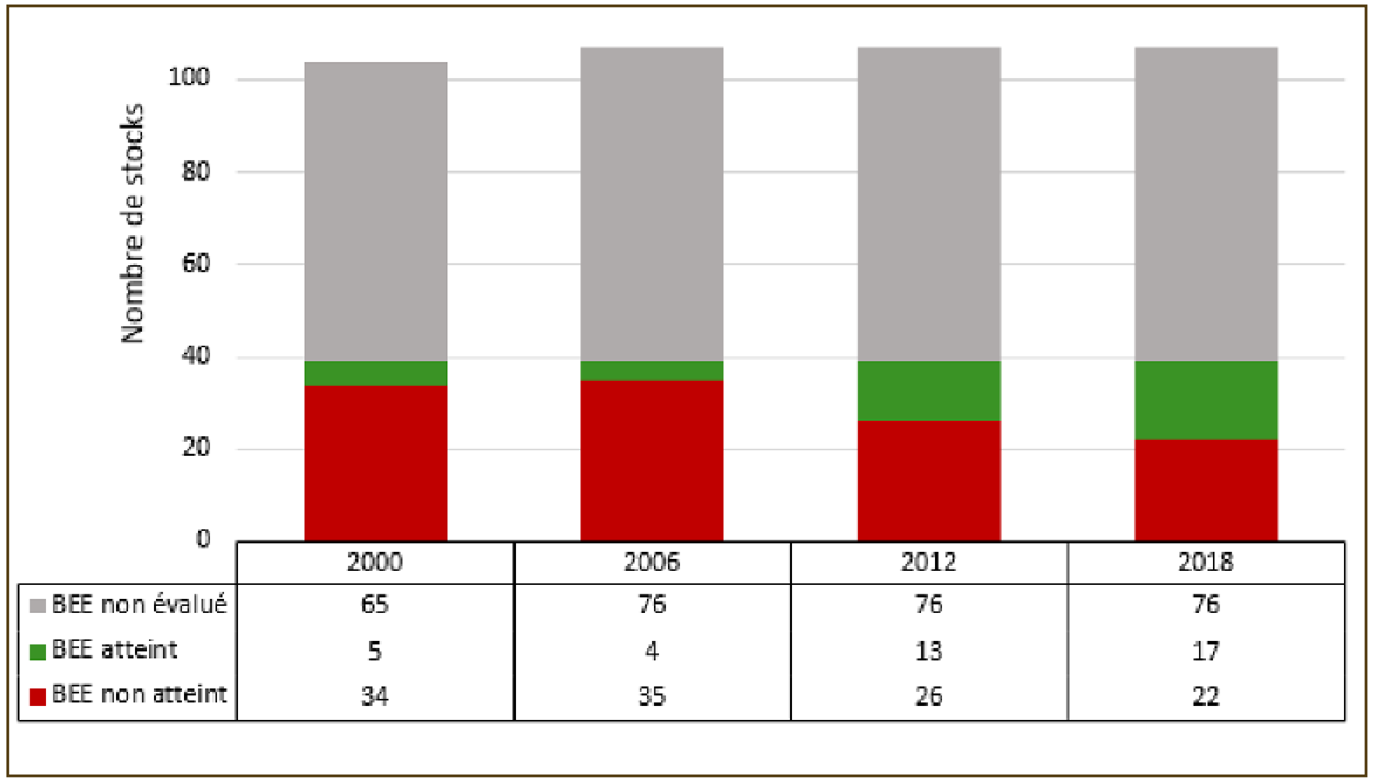



**Figure 14. Distribution of Good Ecological Status according to Descriptor 3, Fish Stock**

Other indicators could be proposed that more closely match the underlying rationale of this class of condition dimensions. For example, an indicator weighing the importance of each stock by its importance in volume or value would be easy to produce and would reflect the threat to human welfare due to existing unsustainable practices.

With more economic valuation techniques, indicators could be derived that estimate the cost of ecosystem degradation, either in terms of loss of services (the foregone benefit due to suboptimal management), or in terms of the costs of the best strategies for stock reconstitution (e.g. through a moratorium). All these valuation exercises would be much more demanding in terms of treatment and could not be readily derived from the accounts through fixed rules and conventions.

# 5. Discussion

Although largely constrained by limited resources, this first experiment to produce marine ecosystem accounts of extent and condition illustrates the feasibility of producing exhaustive accounts for the French EEZ, based on existing published datasets. This exercise shed the light on the many challenges faced as well as the data gaps that prevent easy, systematic, and spatially explicit accounts production. In this section, we discuss methodological challenges and future work needed on marine ecosystem accounting in France.

## 5.1 Implications of spatial analysis methods on accounting for ecosystem extent and conditions

Many trade-offs influenced the methodological choices taken in this experiment. The scale of analysis (French EEZ) and available datasets lead to the use of coarse spatially explicit information, which leads to increased uncertainty and decreased confidence levels in the output. This issue was found both for high resolution inputs that had to be degraded, such as the spatial map of habitats, and for low resolution inputs that had to be extrapolated at the unit of analysis. These restrictions prevent the use of such accounts for specific decision-making, such as to monitor artificialization of the coastline and restoration projects of habitats. These both occur at smaller scales. One possible extension would be to use a finer resolution for the coastal areas, to be able to produce useful information on these subjects.

Marine management is structured around sectoral activities that impact the environment. There are fisheries regional management organizations. There are then spatial marine planning, eutrophication, and extraction of resources in coastal areas. The need for a structured account that aggregates indicators to cover all these issues is therefore not straightforward. On land, the issues and activities are more integrated than in the marine environment, so an integrated accounting effort is useful. In the marine environment, this is not the case. A possible way forward is therefore to focus on the integrated issues that concern the coastal zone, while the offshore issues such as fishing remain in the statistics that are produced in specific policy settings.

One possibility to improve spatial resolution without increasing the need for computing power to produce accounts at the scale of the EEZ would be to use different resolutions for different zones within the EEZ. The zoning used for the evaluation of different indicators of the MSFD, particularly for D5 on eutrophication, could be used here to refine the spatial resolution closer to the coast where policy requires finer scale information to understand ecosystems extent and condition (Figure 15a).

More effort is dedicated to mapping and management of coastal habitats, which could be more appropriately accounted for in a smaller grid (Figure 15b).This resolution could even be differentiated further between the coastal, intermediary, and offshore zones in order to best capture the resolution of different datasets (Figure 16).



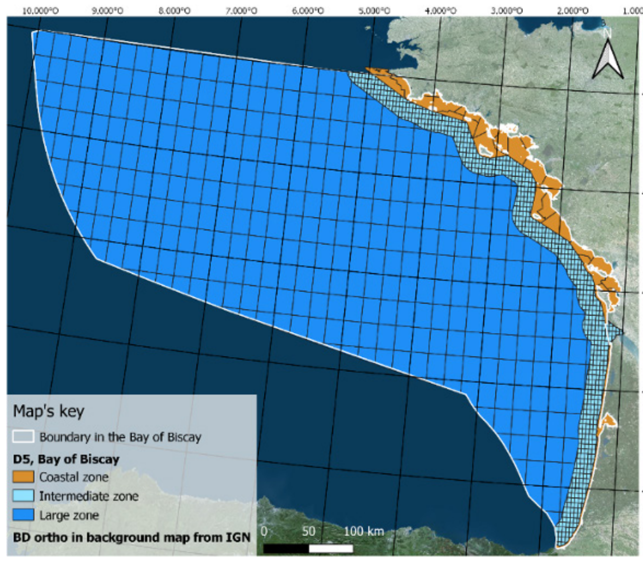



Figure 15a : Categorisation of the three sub-zones with change of the grid in the study of the fifth descriptor[32] by Ifremer

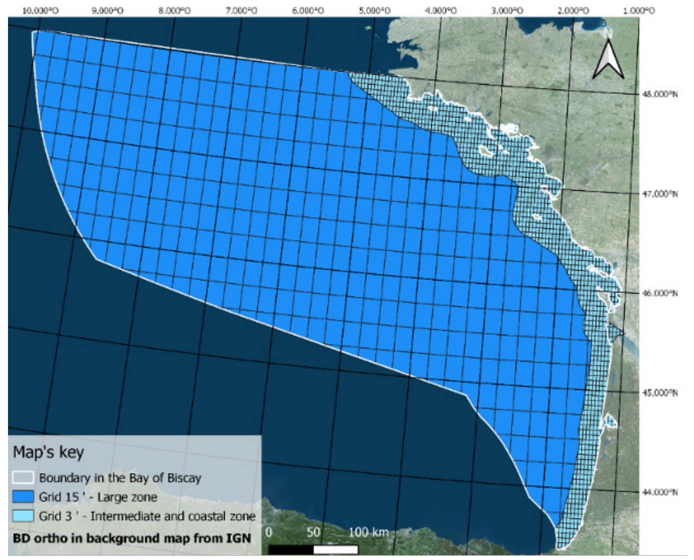



Figure 15b. Categorisation of the two sub-zones with change of the BSU resolution within the grid after merging between the intermediate and coastal zone.

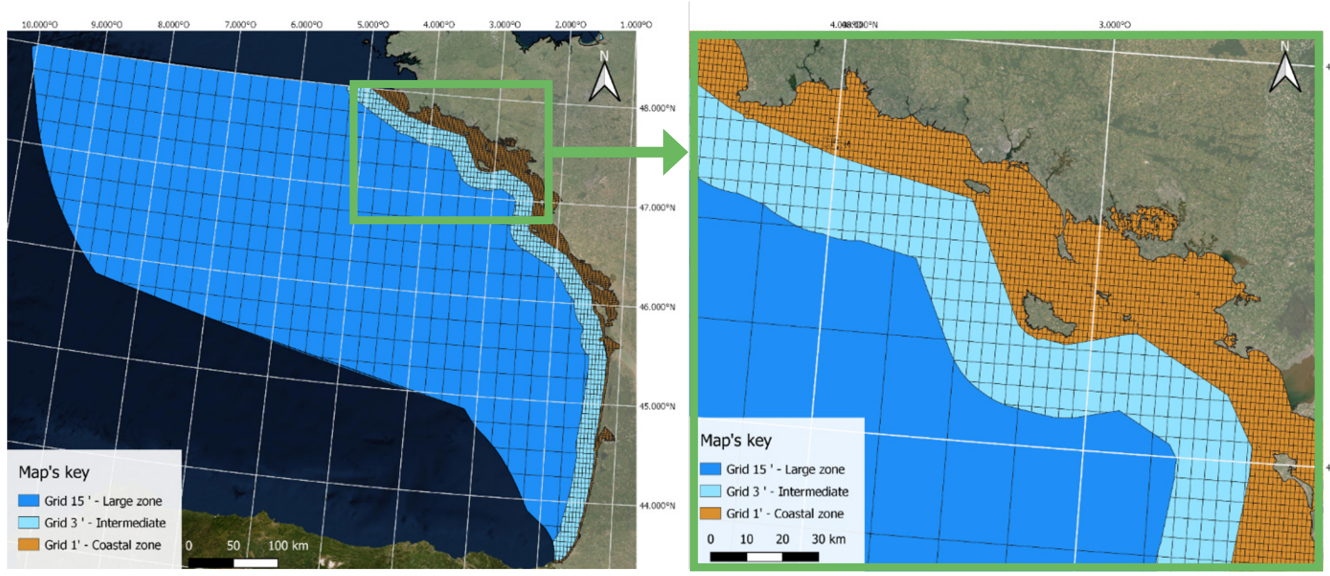



Figure 16. Categorisation of the three sub-zones with change of the BSU resolution within the grid.

Cartographic choices had to be made to produce maps and tables of ecosystem extent that are accurate, standardised, and that can be produced with reasonable resolution and computational power. To check the robustness of the rules that have been applied in this study, we compare the results of our analysis with the results available at the highest precision, using two habitats of community interest: "Maerl beds" (EUNIS class A5.51) and "Sublittoral seagrass beds" (EUNIS class A5.53).

This first approach gives us a summary on the total surface area occupied by the marine habitats in the EEZ. The choice to degrade the information by only keeping the habitat with the highest percentage surface area as the sole value for each cell in our experiment is in line with the spatial model of the SEEA-EA despite the loss of information on the diversity of marine habitats. It is important to measure the loss of information.

32 Devreker David, Lefebvre Alain, Évaluation DCSMM 2018 de l'état d'eutrophisation des eaux marines françaises, Département Océanographie et Dynamique des Écosystèmes Unité Littorale Laboratoire Environnement et Ressources Centre Ifremer Manche Mer du Nord, Septembre 2017, pages 241.

| Total presence of all habitats at high resolution | | Degraded information used in the grid | |
|---|---|---|---|
| Habitat | Surface (%) | Habitat | Surface (%) |
| A6.51 | 16.736 | A6.51 | 16.824 |
| A6.4 | 16.154 | A6.4 | 16.094 |
| A5.15 | 11.424 | A5.15 | 11.442 |
| A5.27 | 10.204 | A5.27 | 10.220 |
| A6.3 | 9.459 | A6.3 | 9.437 |
| A6.52 | 6.223 | A6.52 | 6.231 |
| A5.37 | 5.202 | A5.37 | 5.218 |
| A6.5 | 3.571 | A6.5 | 3.578 |
| A5.14 | 3.249 | A5.14 | 3.261 |
| A5.47 | 1.774 | A5.47 | 1.790 |
| A5.25 | 1.709 | A5.25 | 1.729 |
| A5.23 | 1.151 | A5.23 | 1.450 |
| A5.39 | 1.053 | A5.39 | 1.042 |
| A5.45 | 1.030 | A5.45 | 1.023 |
| A5.44 | 0.917 | A5.46 | 0.977 |
| A5.46 | 0.908 | A5.44 | 0.941 |
| A5.26 | 0.857 | A5.26 | 0.845 |
| A4.1 | 0.683 | A5.13 | 0.695 |
| A5.13 | 0.632 | A4.1 | 0.686 |
| A5.35 | 0.492 | A5.35 | 0.479 |
| A4.33 | 0.457 | A4.33 | 0.452 |
| A6 | 0.388 | A5.53 | 0.442 |
| A5.38 | 0.385 | A3.1 | 0.408 |
| A4.13 | 0.358 | A6 | 0.396 |
| A5.36 | 0.321 | A5.38 | 0.391 |
| A6.2 | 0.306 | A4.13 | 0.370 |
| A3.1 | 0.291 | A5.36 | 0.332 |
| A5.53 | 0.275 | A5.24 | 0.316 |
| A5.24 | 0.238 | A6.2 | 0.284 |
| A4.27 | 0.143 | A5.33 | 0.146 |
| A4.2 | 0.142 | A5.51 | 0.139 |
| A5.51 | 0.129 | A4.2 | 0.125 |
| A5.33 | 0.102 | A4.27 | 0.119 |
| A5.34 | 0.080 | A5.34 | 0.119 |
| A2.24 | 0.070 | A2.24 | 0.112 |
| A5.43 | 0.056 | A5.43 | 0.065 |
| A4.26 | 0.028 | A2.61 | 0.044 |
| A3.31 | 0.028 | A3.31 | 0.032 |
| A3.22 | 0.024 | A3.2 | 0.031 |
| A3.2 | 0.023 | A3.33 | 0.030 |
| Total surface of A5.51 and A5.53 | 0.405 | | 0.581 |

**Table 11. Surface balance of the first forty marine habitats before and after the majority habitats have been established as a percentage of the total surface area in the exclusive economic zone**



Degrading information little affects the percentage distribution of the various habitats, and specifically for the two habitats that interests us here (Table 11). We are therefore confident that degrading the information by using a coarse resolution for the grid used to produce extent accounts are satisfactory at the large scale, but may not be appropriate to inform specific policies.

## 5.2. Methodological Issues to generate extent and condition accounts

The first issue regarding the production of marine ecosystem accounts is the frequency of update of the accounts. It is not clear what is (and will be) the frequency of update of extent of habitat. A project may be launched by the Office Français de la Biodiversité (OFB) on the update of benthic habitats, but no further information could be found. In the European LIFE-MARHA[33] project, there will be an effort to map benthic habitats in Natura 2000 sites. These updated habitat maps could feed into the national-level maps of benthic marine ecosystems extent (this will mean that a composite map is created, which reopens the question of the accounting period for the extent account). There are also existing datasets updated on a regular basis on specific habitats and in specific areas, like seagrasses in the Gulf of Morbihan, Posidonia seagrasses for Mediterranean and Mearl beds for the Atlantic. Other datasets exist at the European level (EMODnet[34]) but it is not clear also if these datasets will be updated regularly.

Two options are available to face the challenge of the ecosystem extent monitoring for marine habitats:

- (i) monitor closely the change in extent of particular benthic habitats (rocky, sandy, Posidonia seagrasses, maerl, mudflats,…) and particular components of the pelagic habitat (plankton/water, body/marine, landscape) which can be considered as proxies of the marine ecosystem extent as a whole or at least contain areas important for policy purposes;

- (ii) use "irreversible" physical degradation based on thresholds that have to be defined in order to consider a physical degradation as irreversible and a habitat as removed and substituted by another one. This approach can help to monitor reduction in the extent of habitats, even if the only information available are on the pressures and conditions. The area where irreversible degradation has occurred then has to be requalified as another type of habitat (to be determined). However, this approach cannot be used to qualify additions to the extent of habitats (other than the additions due to the reductions in the extent of heavily degraded ones).

The datasets used to construct the extent map and account will come from two main sources (Table 12): the CarpeDiem project that mapped benthic habitats, administrative units to describe the pelagic habitats. Alternatively, the European Marine Observation and Data Network (EMODnet) could be used in the future. It features a range of physical, chemical, biological and human activities datasets, which are spatially explicit.

33 Integrated life project on natural marine habitats ("habitat, fauna, flora"). This project includes 8 years. See http://www.aires-marines.fr/Partager/Projets-europeens/Marha-un-projet-Life-integre-sur-les-habitats-naturels-marins and https://www.life-marha.fr/le-life-marha/objectifs

34 The European Marine Observation and Data Network (EMODnet) is a network of organisations supported by the EU's integrated maritime policy. These organisations work together to observe the sea, process the data according to international standards and make that information freely available as interoperable data layers and data products : https://www.emodnet.eu/

EuSeaMap : https://www.emodnet-seabedhabitats.eu/

Table 12. Existing datasets to construct extent account

| Extent type | Description of data layer | Source of data | Classification system | Spatial characteristic | Temporal characteristic | Accessibility |
|---|---|---|---|---|---|---|
| Benthic habitats | Surface of marine habitats | EMODnet | EUNIS | Europe | ? | https://www.emodnet-seabedhabitats.eu/access-data/download-data/ |
| Benthic habitats | Surface of marine habitats | EEA, Corine Land Cover, Europe Seas | EUNIS | Europe | One time reference: 2012 | https://www.eea.europa.eu/data-and-maps/data/ecosystem-types-of-europe-1 |
| Benthic habitats | Surface of marine habitats | OFB, Ifremer | EUNIS | France metropolitan | Composite (2001-2018) | CarpeDiem |
| Benthic habitats | species abundance at point locations | WFD | EUNIS | Surveillance network BenthoVal | Two points: 2012, 2016 | Quadrige/ milieumarin France |
| Pelagic habitats | Phytoplankton abundance: Chlorophyl a | OSPAR PH2 | WFD coastal waters, SHOM MSFD for open ocean | Remote sensing and in-situ data for coastal waters, and modelling | Two points: 1992-2016 | SEXTANT |

## 5.2.2 Methodological issues with the condition account

Each condition indicator will have its own unit. Furthermore, when possible, a reference value should be set to represent existing environmental limits/standards, social norms or policy targets. These represent a gradient of normativity, from limits being mostly science-based to targets being influenced by political considerations. In this report, reference levels will mostly come from the MSFD, and should be considered as both environmental and policy targets since they are the outcome of a political process (reflecting citizens preferences) based on scientific evidence. They reflect environmental goals to reach through collective efforts corresponding to an increase of ecological restoration programs, to a decrease of anthropogenic pressures, etc., which are a source of social and private costs. This is the reason why these required efforts to reach these environmental targets can be considered as a "collective willingness to pay". Some other reference levels, including functioning of ecosystems, are less normative and could be considered limits and/or norms depending on the indicator.

Often, the indicators are measured for an individual station or for the whole water body, not at a fine spatial resolution. This requires defining attribution rules to integrate this information at the level of basic spatial units. Attribution rules will be defined on a case-by-case basis, depending on the nature of the indicator and the specificities of the dataset. The mapped information will be attributed to each basic spatial unit along with a set of characteristics (confidence/uncertainty, nature of information (intensive, extensive, etc.)). In the event some information is lacking, the indicator will be maintained, and lack of information will be reported. This is crucial to identify data gaps and prioritize data acquisition. For example, to the best of our knowledge, marine litter and invasive species cannot be included at this stage for lack of data available. For the capacity to provide regulating services it is sometimes a lack of clear and consensual conceptualization which is an issue.



The typology of dimensions used in this report is not totally aligned with the typology of condition indicators proposed in the SEEA-EA. They propose indicators in three different dimensions to characterize the condition of ecosystems: abiotic ecosystem characteristics, biotic ecosystem characteristics, and landscape level characteristics (Table 13).

Table 13. The SEEA Ecosystem condition typology (ECT). Source: UNSD, 2021

**ECT groups and classes**

***Group A: Abiotic ecosystem characteristics***

**Class A1. Physical state characteristics**: physical descriptors of the abiotic components of the ecosystem (e.g., soil structure, water availability)

**Class A2. Chemical state characteristics**: chemical composition of abiotic ecosystem compartments (e.g., soil nutrient levels, water quality, air pollutant concentrations)

***Group B: Biotic ecosystem characteristics***

**Class B1. Compositional state characteristics:** composition / diversity of ecological communities at a given location and time (e.g., presence / abundance of key species, diversity of relevant species groups)

**Class B2. Structural state characteristics:** aggregate properties (e.g., mass, density) of the whole ecosystem or its main biotic components (e.g., total biomass, canopy coverage, annual maximum normalized difference vegetation index (NDVI))

**Class B3. Functional state characteristics**: summary statistics (e.g., frequency, intensity) of the biological, chemical, and physical interactions between the main ecosystem compartments (e.g., primary productivity, community age, disturbance frequency)

***Group C: Landscape level characteristics***

**Class C1. Landscape and seascape characteristics:** metrics describing mosaics of ecosystem types at coarse (landscape, seascape) spatial scales (e.g., landscape diversity, connectivity, fragmentation)

During the course of this project, we encountered issues with accessing datasets on the condition of fish stocks. The account we produced is coming from data we could access. The MSFD reporting for D3 is based on ICES data, which is mandated by the European Commission to define indicators of good ecological status for fish stocks. The Ifremer produces regularly reports on the state of MSY on metropolitan fish stocks. However, in the timing of the project, we could not access these datasets.

## 5.3 An example of use of ecosystem accounts to study the ecological status of particular ecosystems: habitats of community interest

Benthic habitats are a major component of marine ecosystems by providing essential functions. It is necessary to be able to differentiate them and to know their scientific interest. The EUNIS determination guide organizes and reflects the diversity of benthic habitats. Not only the habitats are determined according to a single determination key but they are also classified from conservation objectives. The aim is to focus on the Community interest. So, for our example , we have concentrated here on "Maerl beds" (A5.51 of EUNIS) and "Sublittoral seagrass beds" (A5.53 of EUNIS). For further information, "Sublittoral seagrass beds" shows a critical state in Europe and requires an important concern on its evolution over time. In addition, if we go further in EUNIS level 5, A5.533 "Zostera beds in full salinity infralittoral sediments" and A5.535 "Posidonia beds" are reported as being of Community interest. After obtaining the extent and condition accounts, the goal is to analyze and discuss possible links between the indicators and the two habitats (Figure 17).

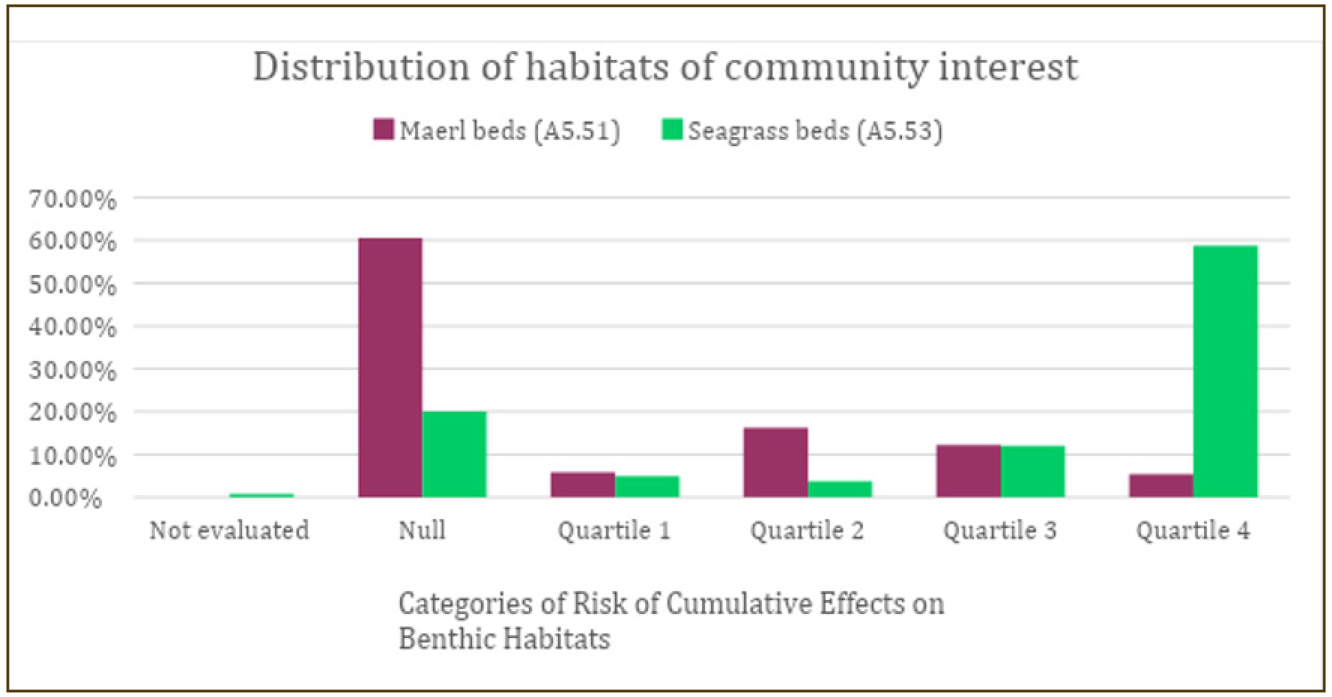



**Figure 17. Distribution of Maerl beds and seagrass beds by quartile of increasing concomitant risk**

In the overall observation of the EUNIS A5.51 maerl beds, it is distinguishable that a large part of the maerl beds do not show any impact on their population from anthropogenic activities (more than 60% of the cells have a CFCR value equal to 0). Moreover, for the remaining cells, the distribution between quartiles does not show a large difference. The seagrass beds show another aspect of the influence of human activities. In the observation of the seagrass beds, it is clearly observable that the seagrass are predominantly in the upper quartile of the cells with the highest risk values for cumulative effects. Therefore, seagrasses are strongly impacted by anthropogenic activities.

- Overseas territories: limited spatial information on marine ecosystems
- Frequency of update of the accounts
- Boundary between marine, coastal, and terrestrial ?

- Communicating uncertainty (linked to resolution, valuation methodologies, data sources) ?
- Articulation with existing databases and institutions (MTES, INSEE, OFB, IFREMER, EMODNET) ?

## 5.4 Future work

If this is instituted over the long term, a coordinator may be needed. Possible institutions to perform this task are the Office français de la biodiversité (OFB) through the Système d'information sur les milieux marins (SIMM), IFREMER, the CGDD[35]/SDES[36], and/or INSEE[37]. Since the CGDD/SDES will be responsible to report on ecosystem accounts for Eurostat, this is the most suited institution to take on this role. The datasets used to produce the accounts rests in different databases with providers, who should allow future accessibility and safe storage. Ultimately, it should be possible to link databases when data is updated from Ifremer/MSFD, SIMM, SDES, and stored in a public infrastructure.

This report is a scientific experimentation on the creation of marine ecosystem accounts of extent and condition for the marine environment. The feasibility of setting up these accounts is tested, but statistical validation of the data is outside the scope of this report. The statistical office in charge of the ecosystem accounts in France, the SDES, has the prerogative to produce such official accounts. We do hope that this report will help in the design and construction of the accounts for France.

- Improvement of the indicators covered for ecosystem condition dimensions

The various datasets used only provide a partial representation of marine ecosystem condition, with a lot of missing indicators (Table 14).There is currently no guideline on constructing capacity metrics. The capacity indicators will be linked to provisioning, cultural[38], regulating, and supporting ecosystem services. For provisioning services, information is collected. For the other services. One way to map capacity could be to produce a matrix of ecosystem habitats with ES supplied (Culhane et al., 2018).

The functionality category is related to states and pressures on the marine environment, as well as its resilience in the face of change. Resilience metrics are not related to descriptors of the MSFD. They could include connectivity, diversity, trophic complexity/redundancy, genetic patrimony, and variability of environmental conditions.

| Dimension | Current condition | Descriptors of the MSFD | Reference condition | Link to policy documents |
|---|---|---|---|---|
| Heritage | • Abundance of species (marine mammals, birds)<br>• Red list<br>• State of protected areas | • D1<br>(• D6) | • Non-declining abundances and surfaces<br>• level of captures<br>• No-net loss of biodiversity<br>• Protection of species and habitats | MSFD, Habitat Directive, OSPAR, Barcelona, Natura2000 |
| Capacity | • Fish stocks<br>• **Water quality** | • D3<br>• **D9** | • MSY<br>• Contaminants levels | MSFD, WFD |
| Functionality | • **Non-indigeneous species**<br>• **Trophic levels**<br>• Physical integrity<br>• Eutrophication<br>• **Marine debris**<br>• **Nurseries & feeding grounds**<br>• **Resilience metrics** | • **D2**<br>• **D4**<br>• D5<br>• D6<br>• **D8**<br>• **D10**<br>• **D11** | • Pollutants levels<br>• Thresholds of chemical and biological variables<br>• Trends in marine debris<br>• Non-declining surfaces | MSFD, OSPAR, WFD |

**Table 14. Availability of reference levels for each descriptors**

Efforts are under way to develop an index of ecosystem conditions that would represent the status of ecosystems in a single number, easily communicated and used. One of the most well-known is the Nature Index developed in Norway (Pederson et al., 2016; Skarpaas et al., 2012). If there is an identified use for index of ecosystem condition, several methodological challenges will have to be resolved. Indicators will be in different units and therefore will have to be normalized, either using the distance to the reference condition or some other normalization variable. Then, aggregation and weighting rules will have to be selected. Weighting could be based on statistical, scientific, or societal importance. Aggregation could be either one form of averaging (arithmetic or geometric) or rule-based.

This experiment was only dedicated to the French metropolitan EEZ. French overseas territories were not considered because no systematic mapping of marine habitats and ecosystem conditions exists there. Maps of coral reefs are available, but are mostly missing for other marine ecosystems, including mangroves, seagrasses, and other substrates.

35 Commissariat général au développement durable : https://www.ecologique-solidaire.gouv.fr/commissariat-general-au-developpement-durable-cgdd

36 Service de la donnée et des études statistiques : https://www.statistiques.developpement-durable.gouv.fr/

37 Institut national de la statistique et des études économiques : https://www.insee.fr/fr/accueil

38 Some cultural ecosystem services aspects are already included in the patrimony category of ecosystem condition, so we will focus on the recreational ecosystem services in the capacity indicators related to cultural ecosystem services.

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# References

Borja, A., Prins, T. C., Simboura, N., Andersen, J. H., Berg, T., Marques, J. C., ... & Uusitalo, L. (2014). Tales from a thousand and one ways to integrate marine ecosystem components when assessing the environmental status. Frontiers in Marine Science, 1, 72.

Comte, A., Kervinio, Y., Levrel, H. (2020). Ecosystem accounting in support of the transition to sustainable societies – the case for a parsimonious and inclusive measurement of ecosystem condition. CIRED Working Paper, 2020-76.

Comte, A., Campagne, S.C., Lange, S., Bruzon, A.G., Santos, F., Hein, L., Levrel, H. (2022). Ecosystem accounting: past scientific developments and future challenges. Ecosystem Services, 58, 101486. https://doi.org/10.1016/j.ecoser.2022.101486

Cordier, M., Agúndez, J. A. P., O'Connor, M., Rochette, S., & Hecq, W. (2011). Quantification of interdependencies between economic systems and ecosystem services: an input–output model applied to the Seine estuary. Ecological economics, 70(9), 1660-1671.

CGDD, 2020. Efese – Du constat à l'action – Rapport de première phase. Septembre 2020.

Culhane, F. E., Frid, C. L., Royo Gelabert, E., White, L., & Robinson, L. A. (2018). Linking marine ecosystems with the services they supply: what are the relevant service providing units?. Ecological Applications, 28(7), 1740-1751.

Devreker David, Lefebvre Alain (2018). Évaluation du descripteur 5 « Eutrophisation » en France métropolitaine. Rapport scientifique pour l'évaluation 2018 au titre de la DCSMM. ODE/LITTORAL/LER.BL/17.08. https://archimer.ifremer.fr/doc/00437/54868/

Devreker David, Lefebvre Alain, Évaluation DCSMM 2018 de l'état d'eutrophisation des eaux marines françaises, Département Océanographie et Dynamique des Écosystèmes Unité Littorale Laboratoire Environnement et Ressources Centre Ifremer Manche Mer du Nord, Septembre 2017, pages 241.

Dvarskas, A. (2019). Experimental ecosystem accounting for coastal and marine areas: a pilot application of the SEEA-EEA in Long Island coastal bays. Marine Policy, 10 141-151.

Ekins, P., & Usubiaga, A. (2019). «Brundtland+30: the continuing need for an indicator of environmental sustainability». In What Next for Sustainable Development?. Cheltenham, UK: Edward Elgar Publishing.

European Commission (2018). Reporting on the 2018 update of articles 8, 9 & 10 for the Marine Strategy Framework Directive. DG Environment, Brussels. pp 72 (MSFD Guidance Document 14).

European Commission (2011). Communication from the Commission to the European Parliament, the Council and the Economic and Social committee and the Committee of the Regions. Our life insurance, our natural capital: an EU biodiversity strategy to 2020.

European Commission, International Monetary Fund, Organisation for Economic Cooperation and Development, United Nations and World Bank (2009). System of National Accounts 2008. Sales No. E.08.XVII.29.

Fenichel, E. P., Addicott, E. T., Grimsrud, K. M., Lange, G. M., Porras, I., & Milligan, B. (2020). Modifying national accounts for sustainable ocean development. Nature Sustainability, 3(11), 889-895.

Franzese, P. P., Buonocore, E., Donnarumma, L., & Russo, G. F. (2017). Natural capital accounting in marine protected areas: The case of the Islands of Ventotene and S. Stefano (Central Italy). Ecological Modelling, 360, 290-299.

Greaker, M., Grimsrud, K., & Lindholt, L. (2017). The potential resource rent from Norwegian fisheries. Marine policy, 84, 156-166.

HELCOM (2018). State of the Baltic Sea - Second HELCOM holistic assessment 2011 - 2016, Baltic Marine Environment Protection Commission.

Hooper, T., Börger, T., Langmead, O., Marcone, O., Rees, S. E., Rendon, O., ... & Austen, M. (2019). Applying the natural capital approach to decision making for the marine environment. Ecosystem Services, 38, 100947.

Ifremer, 2020. Le Bon Etat Ecologique. http://envlit.ifremer.fr/surveillance/strategie_milieu_marin_dcsmm3/le_bon_etat_ecologique, accédé le 23/03/2020

Keith, D. A., Ferrer-Paris, J. R., Nicholson, E., & Kingsford, R. T. (2020). IUCN Global Ecosystem Typology 2.0. Gland: IUCN.

Lai, T.-Y., Salminen, J., Jäppinen, J.-P., Koljonen, S., Mononen, L., Nieminen, E., Oinonen, S.,2018. Bridging the gap between ecosystem service indicators and ecosystem accountingin Finland. Ecol. Model. 377, 51–65.

Levrel, Harold, et al. (2014). «The maintenance costs of marine natural capital: A case study from the initial assessment of the Marine Strategy Framework Directive in France.» Marine Policy 49: 37-47.

Maes, J., Driver, A., Czúcz, B., Keith, H., Jackson, B., Bland, L., Nicholson, E., Dasoo, M. (2019). Discussion paper 2.2: Review of ecosystem condition accounting case studies: Lessons learned and options for developing condition accounts. Paper submitted to the SEEA EEA Technical Committee as input to the revision of the technical recommendations in support of the System.

Martin, J. C., Mongruel, R., & Levrel, H. (2018). Integrating cultural ecosystem services in an ecosystem satellite account: a case study in the Gulf of Saint-Malo (France). Ecological Economics, 143, 141-152.

Mongruel R., Kermagoret C., Carlier A., Scemama P., Le Mao P., Levain A., Ballé-Béganton J., Vaschalde D. & Bailly D., 2019. Assessment of marine and coastal ecosystems and ecosystem services. Synthesis of the study performed for the EFESE programme, IFREMER – UBO – AFB, 26 pages.

Oinonen, S., Hyytiäinen, K., Ahlvik, L., Laamanen, M., Lehtoranta, V., Salojärvi, J., & Virtanen, J. (2016). Cost-effective marine protection-a pragmatic approach. PloS one, 11(1), e0147085.

Pedersen, B., Nybø, S., Sæther, S. A. (eds.) 2016. Nature Index for Norway 2015. Ecological framework, computational methods, database and information systems – NINA Report 1226. 84 pp.

Pettex, E., Lambert, C., Laran, S., Ricart, A., Virgili, A., Falchetto, H., Authier, M., Monestiez, P., Van Canneyt, O., Dorémus, G., Blanck, A., Toison, V. & Ridoux, V. (2014). Suivi Aérien de la Mégafaune Marine en France métropolitaine - Rapport final. Univ. Rochelle UMS 3462 – 169p. DOI : 10.13140/2.1.2698.5287

Quemmerais-Amice F, Barrere J, La Rivière M, Contin G and Bailly D (2020) A Methodology and Tool for Mapping the Risk of Cumulative Effects on Benthic Habitats. Front. Mar. Sci. 7 :569205. doi: 10.3389/fmars.2020.569205

Skarpaas, O., Certain, G., & Nybø, S. (2012). The Norwegian Nature Index–conceptual framework and methodology. Norsk Geografisk Tidsskrift-Norwegian Journal of Geography, 66(5), 250-256.

Stiglitz, J. E., Sen, A. K., & Fitoussi, J. P. (2009). Rapport de la Commission sur la mesure des performances économiques et du progrès social.

UNEP-WCMC (2015) Experimental Biodiversity Accounting as a component of the System of Environmental-Economic Accounting Experimental Ecosystem Accounting (SEEA-EEA). Supporting document to the Advancing the SEEA Experimental Ecosystem Accounting project. United Nations.

United Nations Statistical Division, 2014. System of Environmental-Economic Accounting: Experimental Ecosystem Accounting, Official publication.

United Nations, 2019. Technical Recommendations in support of the System of Environmental-Economic Accounting 2012. ST/ESA/STAT/SER.M/97 ISBN: 978-92-1-161634-7 eISBN: 978-92-1-363101-0.

United Nations, European Union, Food and Agriculture Organization of the United Nations, International Monetary Fund, Organisation for Economic Co-operation and Development, World Bank, 2021. System of Environmental-Economic Accounting—Ecosystem Accounting (SEEA EA) White cover publication, pre-edited text subject to official editing.

Vanhoutte-Brunier Alice, Barrere Julien, Quemmerais-Amice Frédéric (2019). Méthodologie pour la cartographie du risque d'effets concomitants sur les habitats benthiques, v. 5. Office français pour la biodiversité, 98 p.

Vanoli, A. (1995). Reflections on environmental accounting issues. Review of income and wealth, 41(2), 113-137.

Vanoli A., 2015. National accounting and consideration of the Natural heritage. in CGDD (ed.) Nature and the Wealth of Nations - la Revue du CGDD, décembre 2015, pp. 75-84.

Vassallo, P., Paoli, C., Buonocore, E., Franzese, P. P., Russo, G. F., & Povero, P. (2017). Assessing the value of natural capital in marine protected areas: A biophysical and trophodynamic environmental accounting model. Ecological Modelling, 355, 12-17.

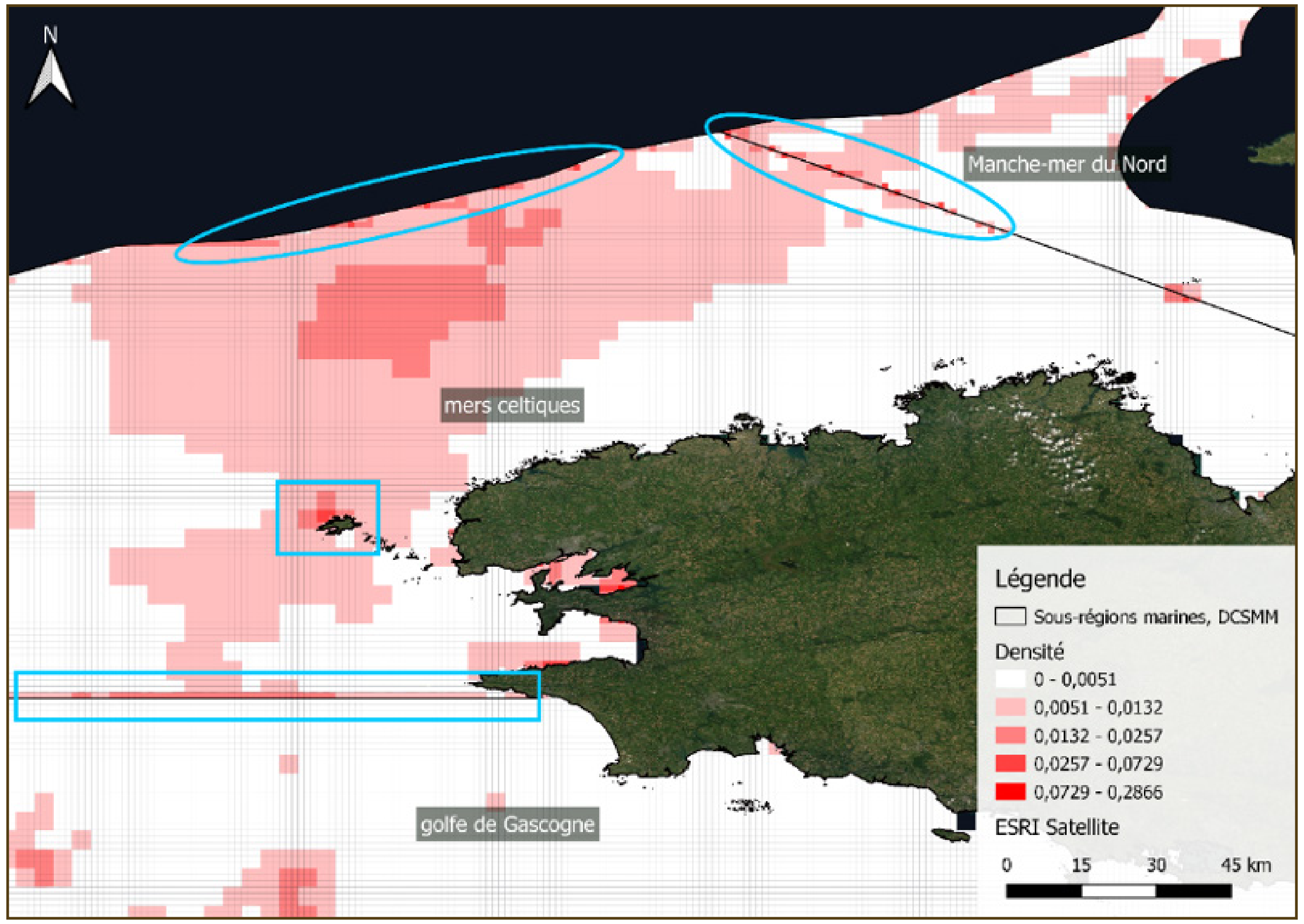
Wang, T., He, G. S., Zhou, Q. L., Gao, J. Z., & Deng, L. J. (2018). Designing a framework for marine ecosystem assets accounting. Ocean & Coastal Management, 163, 92-100.

Weber, J. L. (1983). The French natural patrimony accounts. Statistical journal of the United Nations economic commission for Europe, 1(4), 419-444.

# Annexes

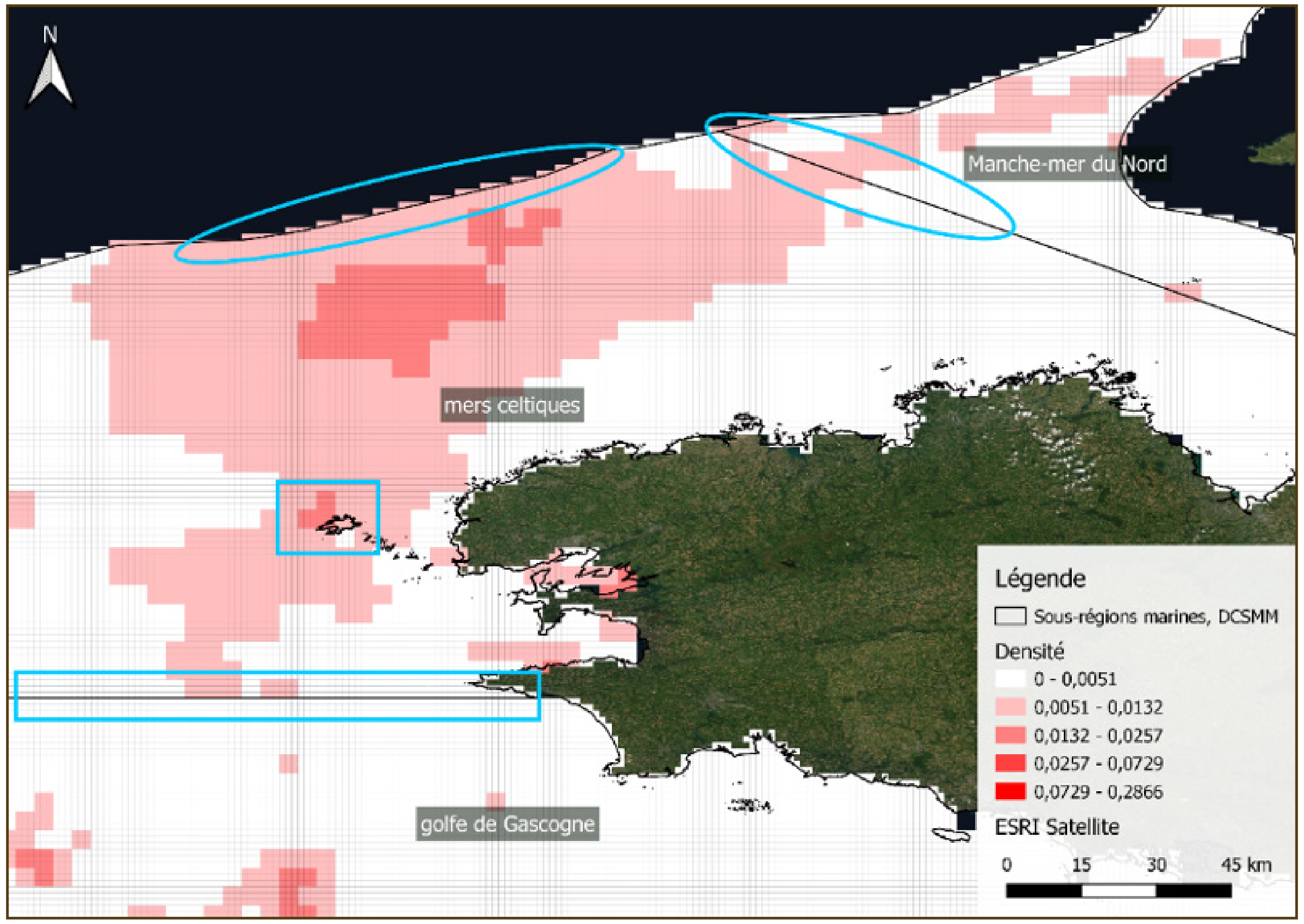
## Annex A: Alignment of the spatial grid with the delineation of marine sub-regions.

Two choices of grid were constructed but only one was chosen to be closest to the SEAA-EA spatial model. The first grid was strictly delimited by the marine sub-regions. The edges of the grid are clean but the results show a few problems at their border.

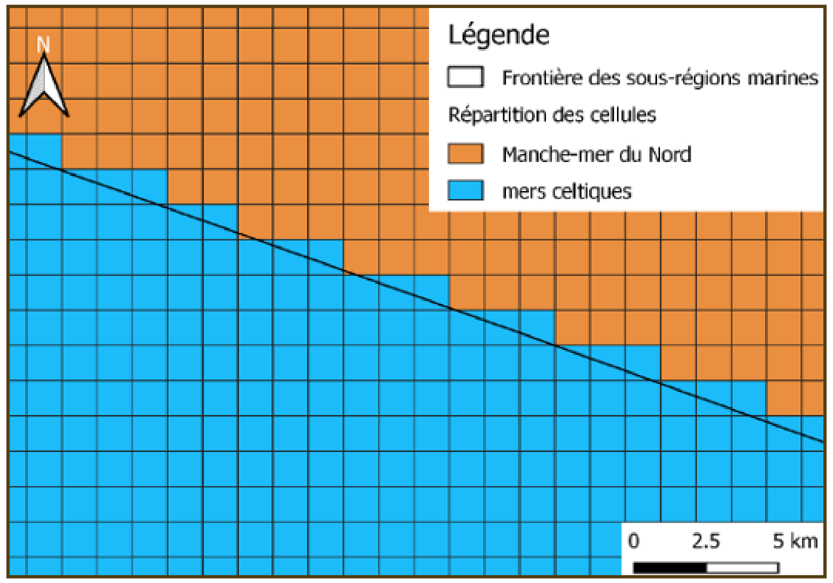



The second grid was also delimited by the marine sub-regions but without changing the cell form in border. So the borders are less clean but the problems have disappeared.






Each cell must belong to a single marine sub-region. So it is necessary to choose in which sub-region the border cells (as below) would be located. We have chosen to keep the same distribution as in the French project CarpeDiem, OFB which has been validated.



# Annex B: Classification des habitats, Code EUNIS

| Code EUNIS | Dénomination EUNIS dans HABREF v4.0 |
|---|---|
| A | HABITATS MARINS |
| A1 | ROCHE ET AUTRES SUBSTRATS DURS INTERTIDAUX |
| A1.1 | Roche intertidale sous fort hydrodynamisme |
| A1.11 | Biocénoses à moules et/ou à balanes |
| A1.111 | Mytilus edulis et balanes sur roche médiolittorale très exposée |
| A1.112 | Chthamalus spp. sur roche exposée du médiolittoral supérieur |
| A1.1121 | Chthamalus montagui et Chthamalus stellatus sur roche exposée du médiolittoral supérieur |
| A1.1122 | Chthamalus spp. et Lichina pygmaea sur roche escarpée et exposée du médiolittoral supérieur |
| A1.113 | Semibalanus balanoides sur roche exposée à modérément exposée ou sur paroi rocheuse verticale abritée médiolittorale |
| A1.1131 | Semibalanus balanoides, Patella vulgata et Littorina spp. sur roche exposée à modérément exposée ou sur paroi rocheuse verticale abritée médiolittorale |
| A1.1132 | Semibalanus balanoides, Fucus vesiculosus et algues rouges sur roche médiolittorale exposée à modérément exposée |
| A1.1133 | Semibalanus balanoides et Littorina spp. sur blocs et galets médiolittoraux exposés à modérément exposés |
| A1.12 | Biocénoses à fucales et/ou à algues rouges résistantes |
| A1.121 | Fucus distichus et Fucus spiralis sur roche extrêmement exposée du médiolittoral supérieur |
| A1.122 | Corallina officinalis sur roche exposée à modérément exposée du médiolittoral inférieur |
| A1.1221 | Corallina officinalis et Mastocarpus stellatus sur roche exposée à modérément exposée du médiolittoral inférieur |
| A1.1222 | Corallina officinalis, Himanthalia elongata et Patella ulyssiponensis sur roche très exposée du médiolittoral inférieur |
| A1.123 | Himanthalia elongata et algues rouges sur roche exposée du médiolittoral inférieur |
| A1.124 | Palmaria palmata sur roche modérément à très exposée du médiolittoral inférieur |
| A1.125 | Mastocarpus stellatus et Chondrus crispus sur roche modérément à très exposée du médiolittoral inférieur |
| A1.126 | Osmundea pinnatifida sur roche modérément exposée du médiolittoral moyen |
| A1.127 | Ceramium sp. et pholades sur tourbe médiolittorale fossilisée |
| A1.13 | Biocénoses de la roche médiolittorale supérieure de Méditerranée et de la mer Noire |
| A1.131 | Association à Bangia atropurpurea |
| A1.132 | Association à Pyropia leucosticta (anciennement Porphyra leucosticta) |
| A1.133 | Association à Nemalion helminthoides et Rissoella verruculosa |
| A1.134 | Association à Lithophyllum papillosum et Polysiphonia spp. |



| Code EUNIS | Dénomination EUNIS dans HABREF v4.0 |
|---|---|
| A1.14 | Biocénoses de la roche médiolittorale inférieure très exposée à l'action des vagues de Méditerranée et de la mer Noire |
| A1.141 | Association à Lithophyllum byssoides |
| A1.142 | Faciès à Mytilus galloprovincialis en présence d'eaux modérément polluées |
| A1.15 | Fucales soumises aux courants de marée |
| A1.151 | Ascophyllum nodosum, éponges et ascidies sur roche du médiolittoral moyen soumise aux courants de marée |
| A1.152 | Fucus serratus, éponges et ascidies sur roche soumise aux courants de marée du médiolittoral inférieur |
| A1.153 | Fucus serratus avec éponges, ascidies et algues rouges sur substrat hétérogène du médiolittoral inférieur soumis aux courants de marée |
| A1.2 | Roche intertidale sous hydrodynamisme modéré |
| A1.21 | Balanes et fucales sur rivages modérément exposés |
| A1.211 | Pelvetia canaliculata et balanes sur roche modérément exposée de la frange littorale |
| A1.212 | Fucus spiralis sur roche du médiolittoral supérieur exposée à modérément exposée en milieu marin |
| A1.213 | Mosaïque de Fucus vesiculosus et de balanes sur roche du médiolittoral moyen modérément exposée |
| A1.214 | Fucus serratus sur roche du médiolittoral inférieur modérément exposée |
| A1.2141 | Fucus serratus et algues rouges sur roche du médiolittoral inférieur modérément exposée |
| A1.2142 | Fucus serratus et faune sous blocs du médiolittoral inférieur exposés à modérément exposés |
| A1.2143 | Fucus serratus et pholades sur roche tendre du médiolittoral inférieur |
| A1.215 | Rhodothamniella floridula sur roche du médiolittoral inférieur abrasée par le sable |
| A1.22 | Moules et fucales sur rivages modérément exposés |
| A1.221 | Mytilus edulis et Fucus vesiculosus sur roche du médiolittoral moyen modérément exposée |
| A1.222 | Mytilus edulis, Fucus serratus et algues rouges sur roche du médiolittoral inférieur modérément exposée |
| A1.223 | Mytilus edulis et pholades sur argile consolidée du médiolittoral |
| A1.23 | Biocénoses de la roche médiolittorale inférieure exposée à l'action des vagues de Méditerranée et de la mer Noire |
| A1.231 | Association à Ceramium ciliatum et Corallina elongata |
| A1.232 | Concrétion de Neogoniolithon brassica-florida |
| A1.233 | Association à Gelidium spp |
| A1.234 | Cuvettes et lagunes parfois associées aux vermets (enclave infralittorale) |
| A1.3 | Roche intertidale sous faible hydrodynamisme |

| Code EUNIS | Dénomination EUNIS dans HABREF v4.0 |
|---|---|
| **A1.31** | **Fucales sur rivages marins abrités** |
| A1.311 | Pelvetia canaliculata sur roche abritée de la frange littorale |
| A1.312 | Fucus spiralis sur roche abritée du médiolittoral supérieur |
| A1.3121 | Fucus spiralis sur roche abritée du médiolittoral supérieur en milieu marin |
| A1.3122 | Fucus spiralis sur substrat hétérogène du médiolittoral supérieur en milieu marin |
| A1.313 | Fucus vesiculosus sur roche abritée à modérément exposée du médiolittoral moyen |
| A1.3131 | Fucus vesiculosus sur roche abritée à modérément exposée du médiolittoral moyen en milieu marin |

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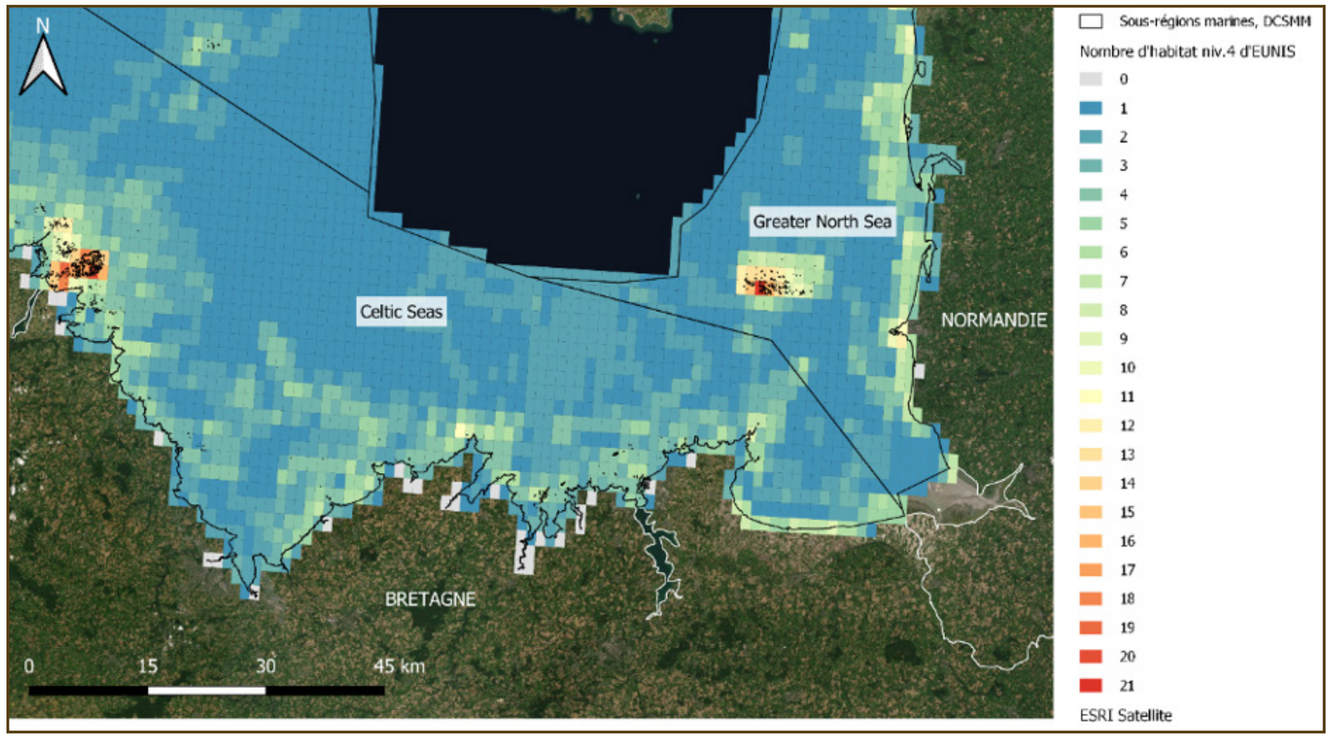
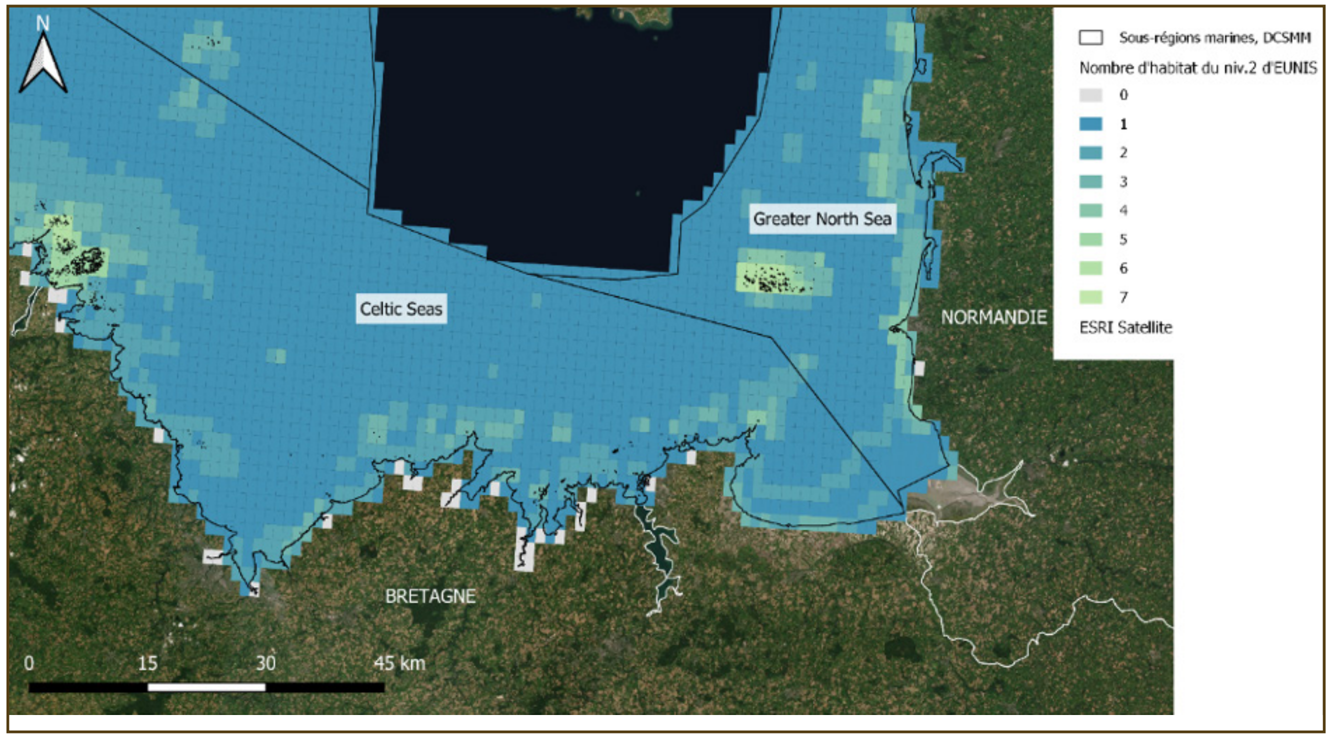
# Annex C: Data from Observatoire National de la Biodiversité

http://indicateurs-biodiversite.naturefrance.fr/fr/indicateurs/tous

| ONB dataset | Spatial coverage | Type of data | Year available |
|---|---|---|---|
| MPA coverage | All French EEZ | Table | 1963-2018 |
| State of conservation of remarkable habitats | All French | Table | 2007-2012 |
| Coral cover trend | Stations, All French EEZ | Table | 2017 |
| State of wetlands | All French | Table | 2011 |
| Pollutants in streams | Metropole | Table | 1998-2016 |
| Pesticides in streams | Metropole | Table | 2008-2016 |
| Pesticides in streams | Outre-mer | Table | 2008-2016 |
| Change in habitats ZNIEFF | Metropole | Table | 1990-2012 |
| Number of exotic species introduced | Metropole | Table | 1949-2018 |
| Exotic species among the most invasive worldwide | Outre-mer | Table | 2016 |
| MPAs with DOCOB | All French EEZ | Table | 1998-2018 |
| Data on level of knowledge of species or habitats | All French | Table | To take or not??? |
| Functional habitats in good conservation status | Metropole | Table | 2007-2012 |
| Territory not “anthropized” | Metropole | Table | 1990-2012 |
| Territory not “anthropized” | Outre-mer | Table | 1990-2012 |
| Habitats destroyed | Outre-mer | Table | 2000-2012 |
| Red List | All French | Table | 2018 |
| Mangroves under pressure | Outre-mer | Not available yet | ? |
| Quality of surface waters according to WFD | All French waters + coastal | Table | 2018 |
| Increase/decrease wetlands | Metropole | Table | 2000-2010 |
| Degradation/restoration wetlands | Metropole | Table | 2000-2010 |
| Dragages in ports | Metropole | Table | 2006-2015 |
| Demographic pressure on coastline | Metropole | Table | 2013 |
| Number of species with at least one data point | All French | Table | 2018 |

Comparison between the number of marine habitats by fixing at level 2 and 4 of EUNIS code.






# Annex D: Code used for data processing and analysis

**PostgreSQL** v.12.2.1 linked to the **PostGIS** v.3 extension and the development platform **pgAdmin** 4, v.4.19

PostgreSQL is a relational and object-oriented database management system. Linked to its PostGIS extension, this system allows the manipulation of geographic data and the creation of spatialized databases.

1. Free access to use.
2. Design dedicated to database architecture.
3. Programming by SQL queries: This computer language gives access to communication with a database. It gives rise to the selection, creation, updating and deletion of data.
4. Handling of heavy data.
5. Improvement of calculation times possible from spatial indexes.
6. Statistical evaluation of data can be carried out by using primary and foreign keys between the tables. These keys are indispensable when it is necessary to link the tables of a database together to make aggregations or comparisons.

**QGIS v.3.10.0**

1. Free GIS software.
2. Visualization of project vector layers.
3. Access to the modification and processing of the layers from the numerous tools available.
4. Important solicitation during the project as a source of evaluation on the coherence of the results.
5. Contribution to the elaboration of the final cartographic renderings.

**Programmation sous R** v.3.6.1 avec **Rstudio** v.1.2.5001

Programming environment to automate certain treatments.

**Excel**

1. Initial visualization of source data.
2. Organization of the final statistical tables on the extent and condition accounts according to the study area and the two marine zones, Benthic and Pelagic.

# Méthode – Mammifères marins et Oiseaux

## Rééchantillonnage de la densité

PostgreSQL (pgAdmin4) / R / QGIS

Solène Legrand

A partir des données sources sur les mammifères marins et les oiseaux, il a été nécessaire d'harmoniser et de synthétiser les données pour les transférer dans la nouvelle grille à 1/60ème de degré.

Remarque : La grille à 1/60ème de degré n'est autre qu'une des 3 grilles proposées dans le projet Carpediem, mais qui a été réajustée pour concorder à nos besoins.

- Voir Fiche Méthode : conception de la grille – 1 minutes d'arc

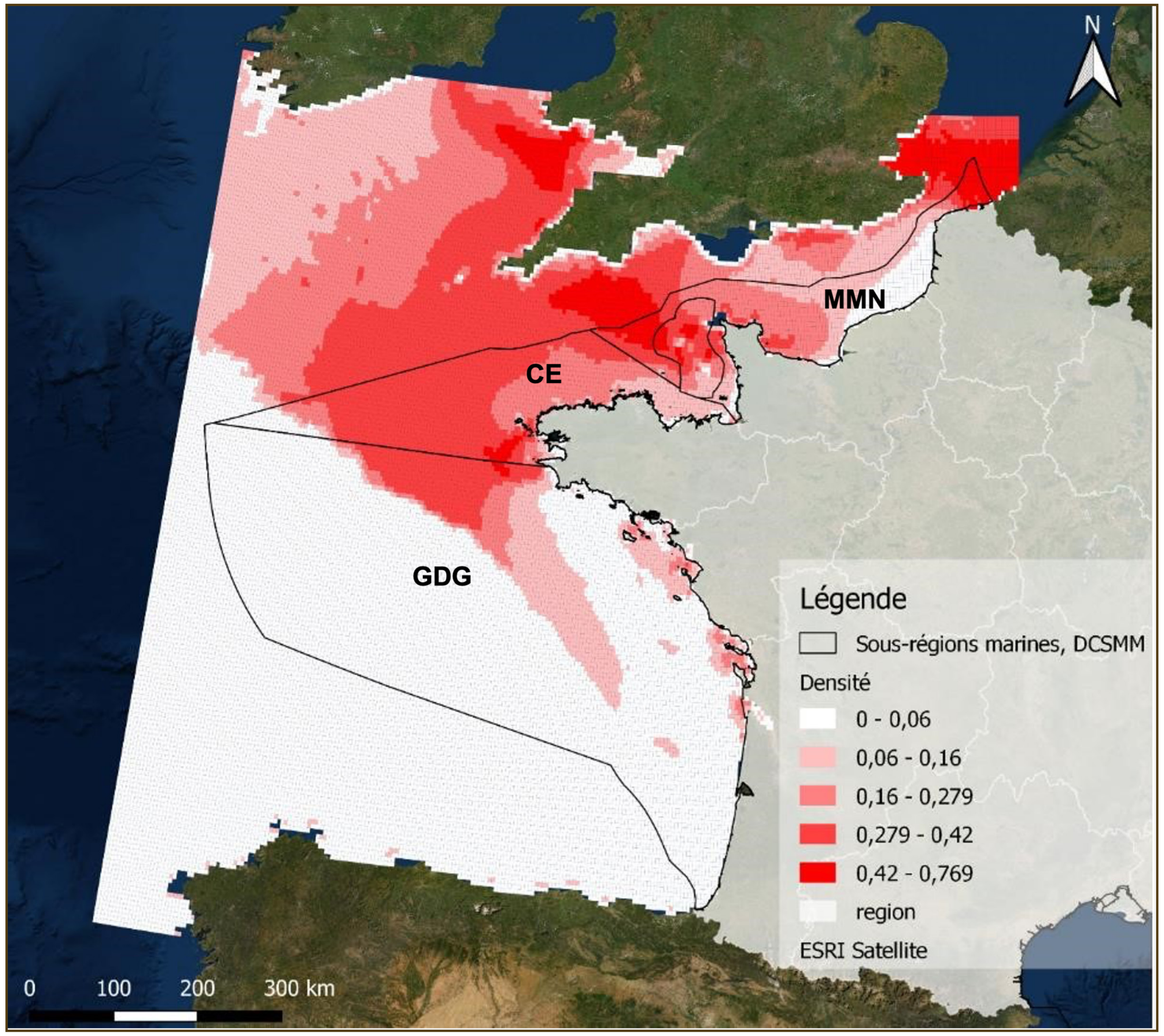
## Descriptif des données sources

Source :

- Projet Carpediem, 2018 – 2019. Distribution spatiale de la prédiction de densité de plusieurs groupes d'espèces, mammifères marins et oiseaux, en France métropolitaine.
  - Support : maillage de 3/60ème de degré
  - Format : Shapefile
  - Géométrie : Polygone
  - Système de projection : WGS84 / Unité : degré (latitude, longitude)
- DCSMM, Sous-régions marines, France provenant de : https://geo.data.gouv.fr/. « Parties françaises des sous-régions marines européennes : découpage géographique utilisé en application de la directive cadre stratégie milieu marin (DCSMM) »[39].
  - Format : Shapefile
  - Géométrie : Polygone
  - Système de projection : WGS84 / Unité : degré (latitude, longitude)
- Listes rouges de l'UICN sur les mammifères marines et les oiseaux récoltées sur le site de l'INPN : « outils de connaissance » qui informent sur les risques encourus par la biodiversité. ....Format : CSV
- Liste des mammifères marins protégés sur le territoire national et les modalités de leur protection
  - Format : CSV
- Liste des oiseaux protégés sur l'ensemble du territoire et les modalités de leur protection
  - Format : CSV

39 https://geo.data.gouv.fr/fr/datasets/b6a9af6b5517fbd15a4d566708b09221e987f39c






**Distribution spatiale de la prédiction de densité des marsouins sur la côte française Ouest en 2012.**
**Source : Projet Carpediem, DCSMM, https://www.data.gouv.fr/ Système de projection (Visualisation) : Lambert 93**

## Méthode : Union des multiples informations sur les mammifères marins et les oiseaux dans la grille d'étude – QGIS, Requêtes SQL et programmation sous R

**1ère phase sur QGIS : Réarrangement des valeurs de densité sur les mammifères marins et les oiseaux selon la grille** Toute la méthode, ci-dessous, sera présentée uniquement pour les données sur les oiseaux. En effet, les données sources oiseaux et mammifères marins ont été construites sur le même profil ce qui demande juste de répéter cette même méthode pour les mammifères marins.

- Ajoutez toutes les couches shapefiles sur les oiseaux dans QGIS comme suit :

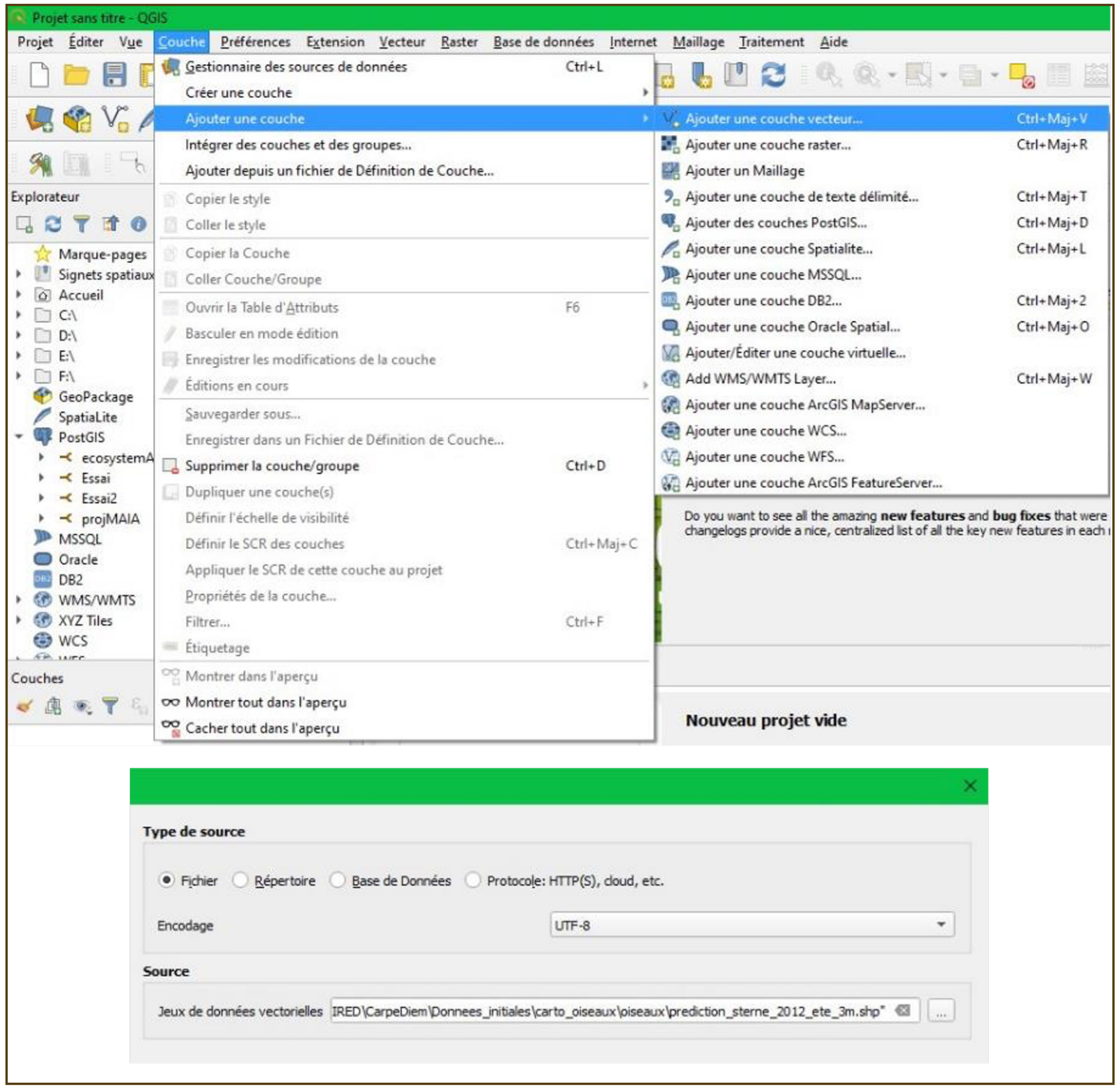



**Figure 1 : Comment ajouter une nouvelle couche vecteur sur QGIS.**
**Astuce : Il est possible de sélectionner toutes les couches visées et les ajouter toutes en même temps.**

- Allez dans la table d'attribut dans une des données sources en faisant un clic droit, « Ouvrir la table d'attributs ».

- Ajoutez de nouvelles colonnes en ouvrant la calculatrice de champ

Info : Cette étape permet d'ajouter certaines informations manquantes sur les couches. En effet, cela permettra par la suite de dissocier chaque groupe d'espèces après agrégation de tous les oiseaux dans une unique couche.

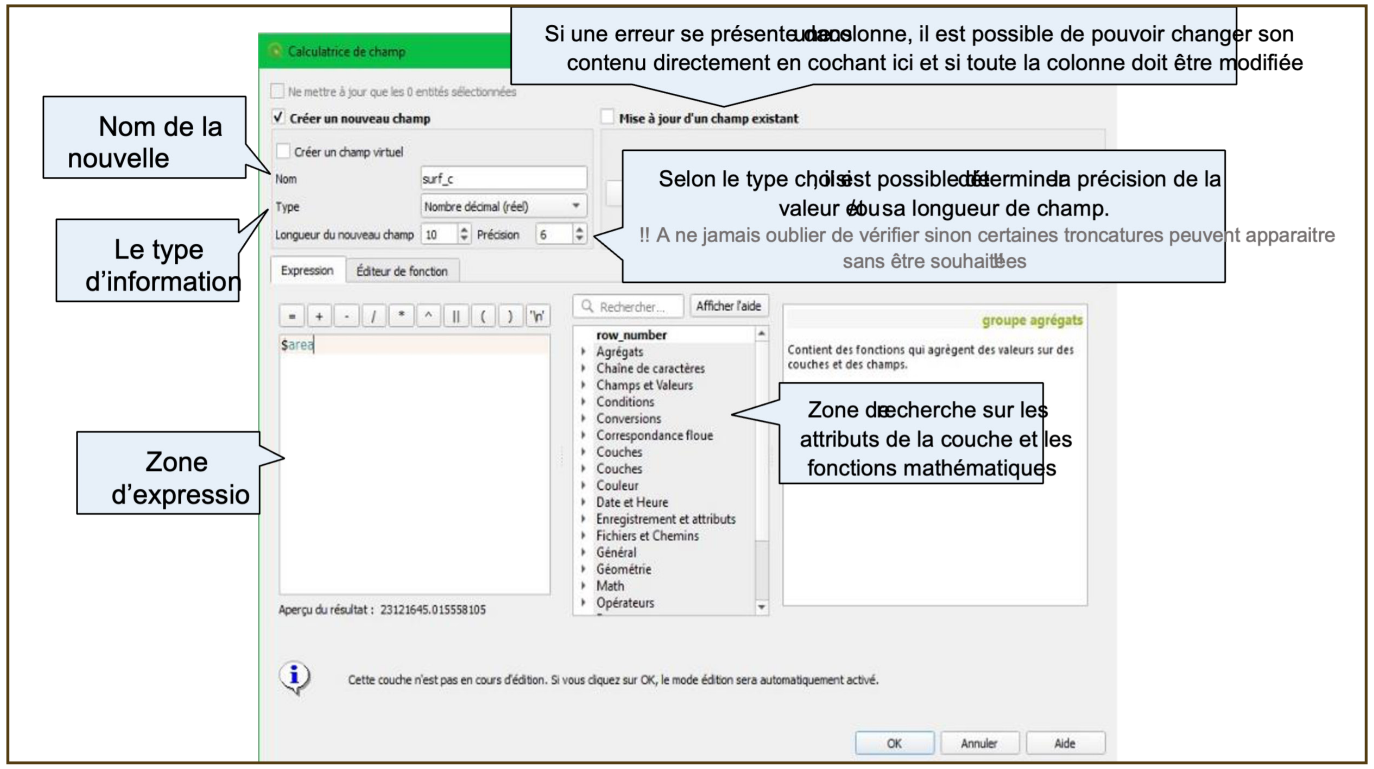



**Figure 2 : Exemple de remplissage de la calculatrice de champ**

- « gp_espece » de type « texte chaîne de caractère » et ajouter dans la zone d'expression 'grands puffins' par exemple, nom attribué à la donnée et au groupe d'espèces.

- « esp_lat» de type « texte chaîne de caractère » et ajouter dans la zone d'expression 'puffinus gravis / puffinus griseus / calonectris diomedea' par exemple, noms latins de chaque espèce composant le groupe.

**Aide : Voir figure 3 qui dispose de tous les noms d'espèces et des groupes d'espèces d'oiseaux. Maintenant, !! certaines espèces ont des noms latins qui peuvent varier selon les études. Conséquence : Ces noms latins vont être repris durant le programme sous R pour déterminer la classification UICN des groupes d'espèces. Certaines espèces ne seront pas prises en compte si le nom n'est pas totalement identique à celui qui est noté dans la liste rouge. Donc elles n'influeront pas sur la classification finale du groupe. A vérifier et à modifier si nécessaire !!** Exemple « Océanites » :

  - Liste rouge : « hydrobates pelagicus / oceanodroma leucorhoa / oceanodroma castro »
  - Projet Carpediem : « hydrobates pelagicus / hydrobates leucorhous / hydrobates castro ».

- « prot_esp » de type « texte chaîne de caractère » et ajouter dans la zone d'expression 'yes' ou 'no' par exemple, caractérise si ce groupe fait partis des espèces protégées selon l'INPN. **Aide : Voir la liste des espèces protégées récupérée sur le site de l'INPN.**

- « saison » de type « texte chaîne de caractère » et ajouter dans la zone d'expression 'été' ou 'hiver' par exemple, ces groupes d'espèces ont été étudié sur deux périodes (= deux saisons), été et hiver.

- « annee » de type « texte chaîne de caractère » et ajouter dans la zone d'expression '2012'. Par exemple, l'année d'observation.

- « surf_c » de type « Nombre décimal (réel) » avec une précision de 3 (ou 6) et ajouter dans la zone d'expression « $area », surface de la cellule.

**Remarque : Il n'est pas nécessaire de se préoccuper de l'unité car cela servira à calculer le ratio de deux surfaces ayant la même unité.**

| OISEAUX | | | |
|---|---|---|---|
| **Famille** | **Groupe ou espèces** | **Nom latin** | **Espèces associées** |
| Alcidés | Alcidés | *Fratercula arctica* | Macareux moine |
| | | *Uria aalge* | Guillemot de Troil |
| | | *Alca torda* | Pingouin torda |
| Phalacrocoracidae | Cormorans | *Phalacrocorax carbo* | Grand cormoran |
| | | *Phalacrocorax aristotelis* | Cormoran huppé |
| Sulidae | Fou de Bassan | *Morus bassanus* | - |
| Procellariidae | Fulmar boréal | *Fulmarus glacialis* | - |
| | Petits puffins | *Puffinus puffinus* | Puffin des anglais |
| | | *Puffinus yelkouan* | Puffin yelkouan |
| | | *Puffinus mauretanicus* | Puffin des Baléares |
| | Grands puffins | *Puffinus gravis* | Puffin majeur |
| | | *Puffinus griseus* | Puffin fuligineux |
| | | *Calonectris diomedea* | Puffin cendré |
| Laridae | Grand goéland gris | *Larus argentatus* | Goéland argenté |
| | | *Larus michahellis* | Goéland leucophée |
| | Grand goéland noir | *Larus marinus* | Goéland marin |
| | | *Larus fuscus* | Goéland brun |
| | Sternes | *Sterna paradisaea* | Sterne arctique |
| | | *Sterna hirundo* | Sterne pierregarin |
| | | *Sterna albifrons* | Sterne naine |
| | | *Thalasseus sandvicensis* | Sterne caugek |
| | Mouettes | *Larus ridibundus* | Mouette rieuse |
| | | *Larus melanocephalus* | Mouette mélanocéphale |
| | Mouette pigmée | *Larus minutus* | - |
| | Mouette tridactyle | *Rissa tridactyla* | - |
| Hydrobatidae | Océanites | *Hydrobates pelagicus* | Océanite tempête |
| | | *Hydrobates leucorhous* | Océanite culblanc |
| | | *Hydrobates castro* | Océanite de Castro |
| Stercorariidae | Grand labbe | *Catharacta skua* | - |
| Anatidae | Macreuses | *Melanitta nigra* | Macreuse noire |
| | | *Melanitta fusca* | Macreuse brune |
| Gavidae | Plongeons | *Gavia stellata* | Plongeon catmarin |
| | | *Gavia arctica* | Plongeon arctique |
| | | *Gavia immer* | Plongeon imbrin |

**Figure 3 : Listes des groupes d'espèces d'oiseaux étudiées dans le projet CarpeDiem[40]**

- Puis sauvegardez la couche en quittant le mode édition.

- Faire la même manipulation sur toutes les autres couches.

- Intersectez avec l'outil QGIS Intersection , entre la grille d'étude et la donnée en oubliant pas d'enregistrer le résultat obtenu dans un dossier spécifique et en choisissant les attributs à garder.

**Aide : Les attributs à garder absolument sont id2 et pk pour la grille d'étude et espace, density, density_cv et bien sûr toutes les nouvelles colonnes créées précédemment.**

**Remarque : L'indication de l'espace (Atlantique ou Méditerranée) pour situer les cellules est important en raison des différences possibles de classification de l'UICN chez les espèces selon l'espace.**

40 Provenant du rapport : « Méthodologie employée pour le formatage des données de modélisation d'habitat des mammifères marins et oiseaux marins » par Fanny Bliard, Chargée de mission géomatique dans le cadre du projet SIMNORAT, 2018.



- Ensuite dans ce nouveau shapefile, ouvrir la table d'attribut.

- Maintenant le but est de recalculer les nouvelles densités :

« Ouvrir la calculatrice de champs » et ajoutez ces quatre nouvelles colonnes : o surf_int, type « Nombre décimal (réel) », précision de 6, expression : $area o ratio_surf, type « Nombre décimal (réel) », précision de 6, expression : « surf_int »/ « surf_c » o d, type « Nombre décimal (réel) », précision de 6, expression : « ratio_surf »* « density »

- d_cv, type « Nombre décimal (réel) », précision de 6, expression : « ratio_surf »* « density_cv »

- Puis sauvegardez la couche en quittant le mode édition

- Ouvrir « DB Manager… » de QGIS dans l'onglet « Base de données ».

- Sélectionner la BDD qui va récupérer la donnée dans la fenêtre « Fournisseurs de données » > « PostGIS »,

PostGIS → ecosystemAccounting

Double-clic sur la BDD > Demande de connexion

Importez la couche Import de couche/fichier , comme suit :

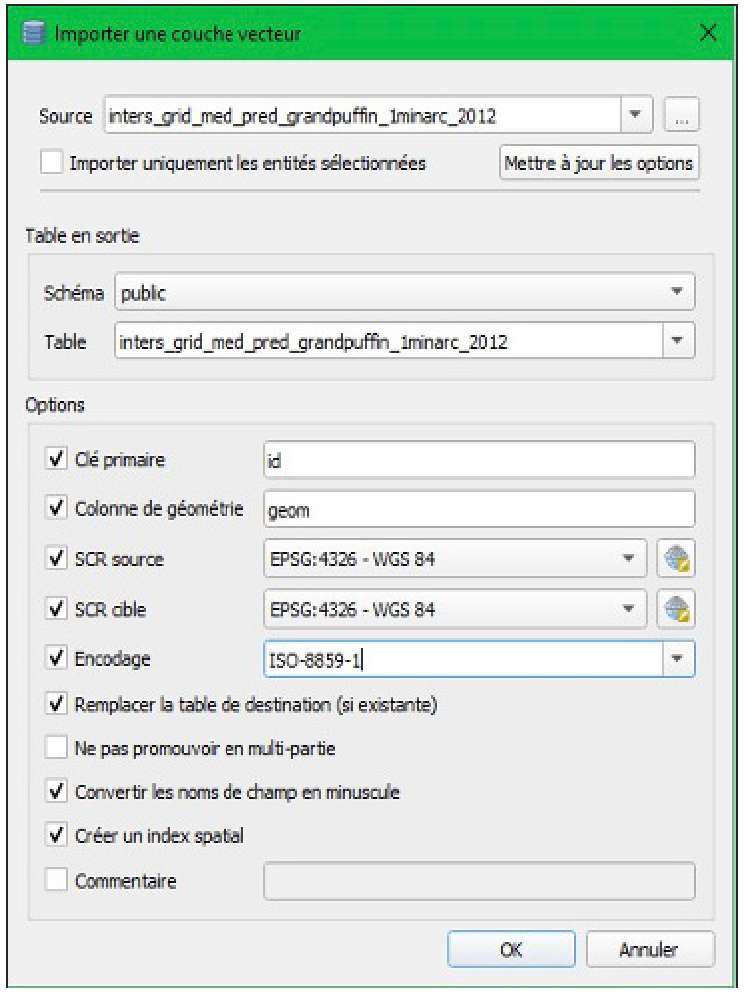



**Figure 4 : Importation des fichiers dans la base de données à partir du gestionnaire de BDD de QGIS**

Toutes couches déjà chargées dans le projet QGIS sont proposées dans le bande déroulante « Source », mais il est aussi possible d'aller chercher le fichier « .shp » demandé dans les dossiers en appuyant sur « … ».

- Choisir le nom du schéma. Aide : Il est préférable de choisir le schéma public qui contiendra principalement les tables intermédiaires et laisser les autres schémas pour une visualisation claire de la BDD finale.

- Le nom de la table souhaité. Choisir un nom clair et représentatif. o Et cocher toutes les cases comme ci-dessus. Aide : Ne surtout pas oublier l'encodage et l'index spatial !

**Remarque : Vérifier que les caractères spéciaux soient bien passés en ouvrant les tables dans pgAdmin4 avant de faire la suite.**

- Après que tous les fichiers ont été importés avec succès dans la BDD, il est possible de programmer par requêtes SQL sur ces nouvelles tables. Or l'harmonisation de la densité n'est pas encore complète. Pour cela, ouvrir une fenêtre SQL après sélection de la BDD, et ajouter puis exécuter :

  CREATE TABLE grid_pred_mouette_1_minarc_2011



# Méthode – Descripteur 5, Eutrophisation

## Rééchantillonnage

PostgreSQL (pgAdmin4) / QGIS

Solène Legrand

Le but de cette méthode est de rééchantillonner les valeurs du descripteur 5 dans toute la nouvelle grille après transfert des données sources. Pour cela, la démarche se divise en trois parties.

## Descriptif des données sources

- DCSMM2018 – D5 : Concentrations en nutriments dans les unités géographiques d'évaluation des sous régions marines (2010-2016) o Nombre de données : 4, pour les quatre sous-régions marines o Format : Shapefile o Géométrie : Polygone o Système de projection : WGS84

- DCSMM, Sous-régions marines, France provenant de : https://geo.data.gouv.fr/. « Parties françaises des sous-régions marines européennes : découpage géographique utilisé en application de la directive cadre stratégie milieu marin (DCSMM) »[41]. o Format : Shapefile o Géométrie : Polygone o Système de projection : WGS84 / Unité : degré (latitude, longitude)

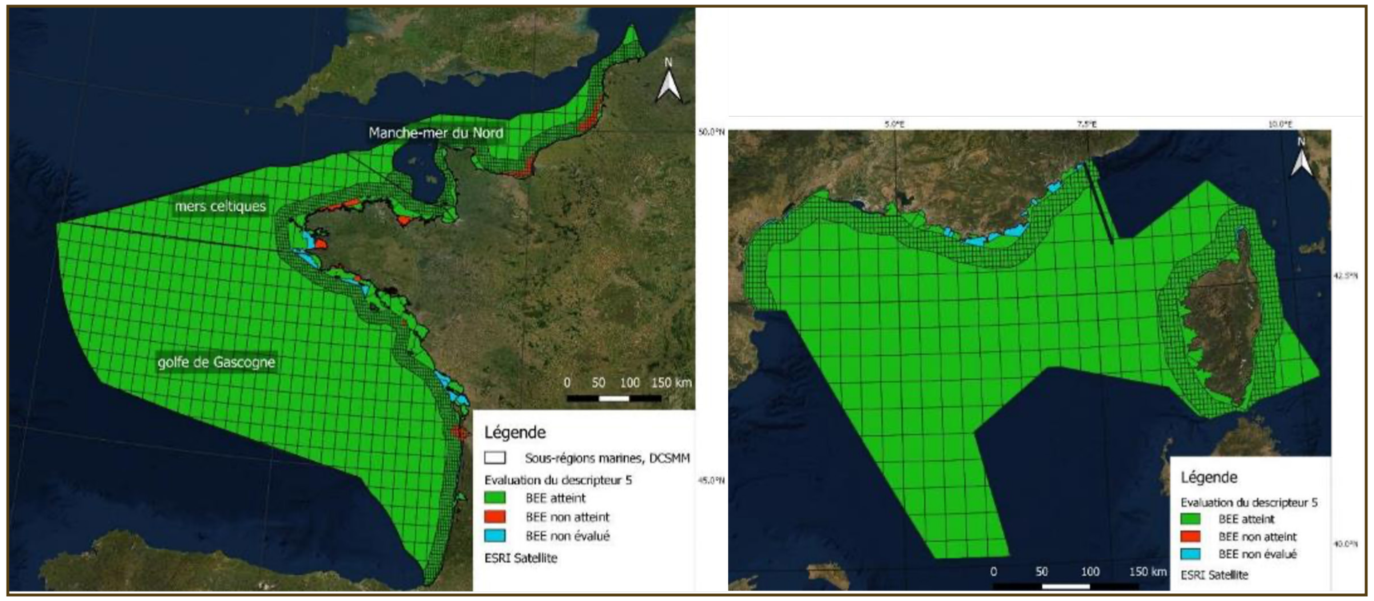



**Figure 0 : Distribution spatiale du Bon état écologique du descripteur 5 selon 6 de ses critères en France Métropolitaine**

## 1. Première étape : Transfert des valeurs vers leurs nouvelles entités spatiales

QGIS : Intersection entre la grille 1 minute d'arc et les couches vecteurs sources correspondant au descripteur 5 (eutrophisation)[42].

- Ajouter les couches sources sur le D5 dans QGIS. Pour cela, aller dans l'onglet « Couche » > « Ajouter une couche… » > « Ajouter une couche vecteur… ». Choisir l'encodage (je recommande de prendre en UTF-8) et rechercher les couches vecteurs souhaitées.

41 https://geo.data.gouv.fr/fr/datasets/b6a9af6b5517fbd15a4d566708b09221e987f39c
42 https://sextant.ifremer.fr/Donnees/Catalogue#/metadata/41331267-6538-4902-8b6e-13aa67f0a49f

- Ici les couches sources se nomment : « **DCSMM2018_D5_MMN.shp** », « **DCSMM2018_D5_MC.shp** », « **DCSMM2018_D5_GDG.shp** » et « **DCSMM2018_D5_MO.shp** ».

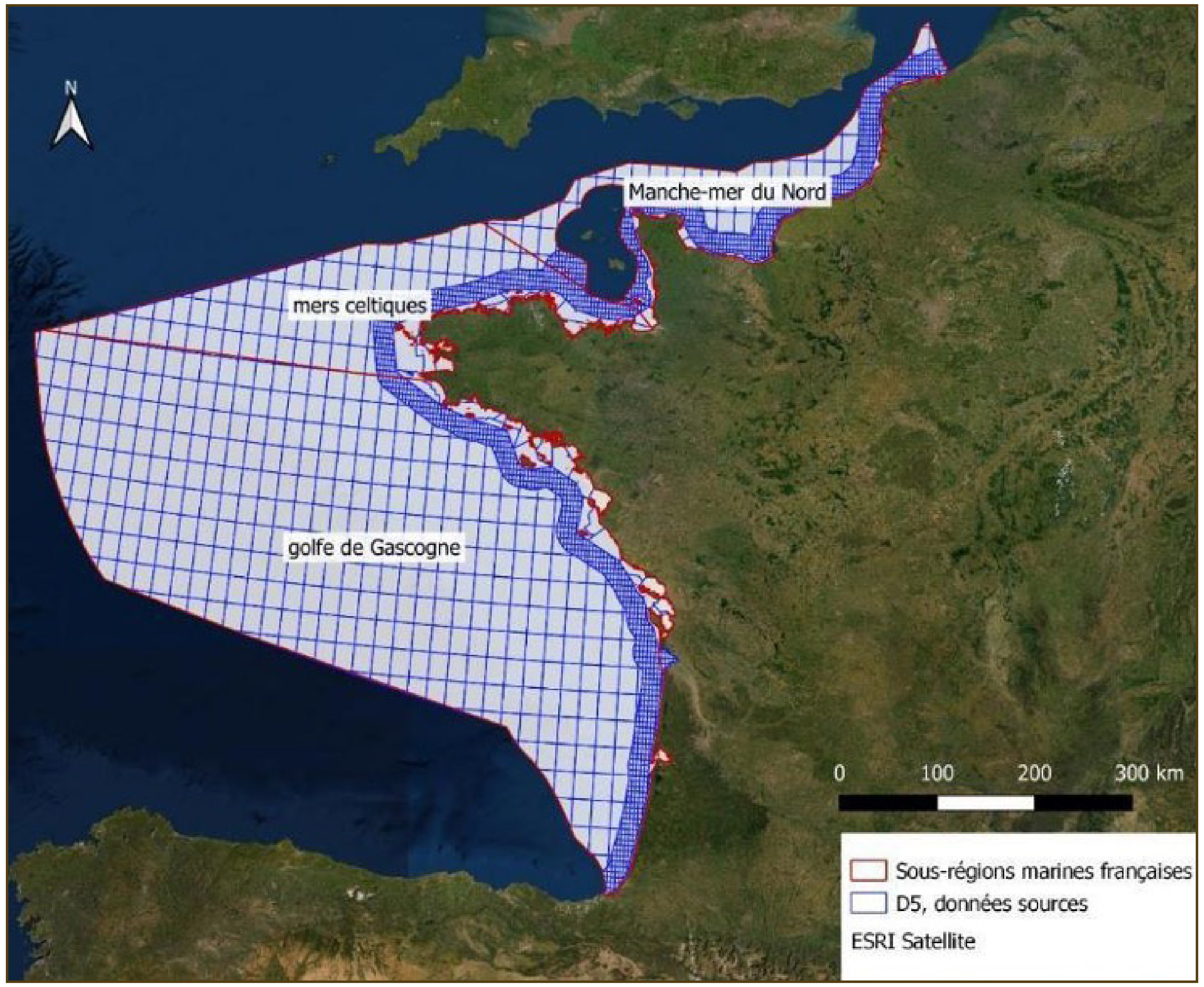



**Figure 1 : Visualisation des données sources sur le descripteur 5, l'Eutrophisation, sur la côte Atlantique**

- Utilisation de l'outil « Intersection », Intersection , dans la boite à outils de QGIS.

  Remarque : il peut être judicieux de diviser selon l'espace Atlantique et Méditerranéen pour diminuer le temps de calcul. Pour cela, il est nécessaire de fusionner les couches, D5 MMN, CEL et GDG en utilisant l'outil fusion de QGIS ( Fusionner des couches vecteur choisir les couches en entrée, SCR de destination : 4326 et ... : enregistrer vers un fichier …).



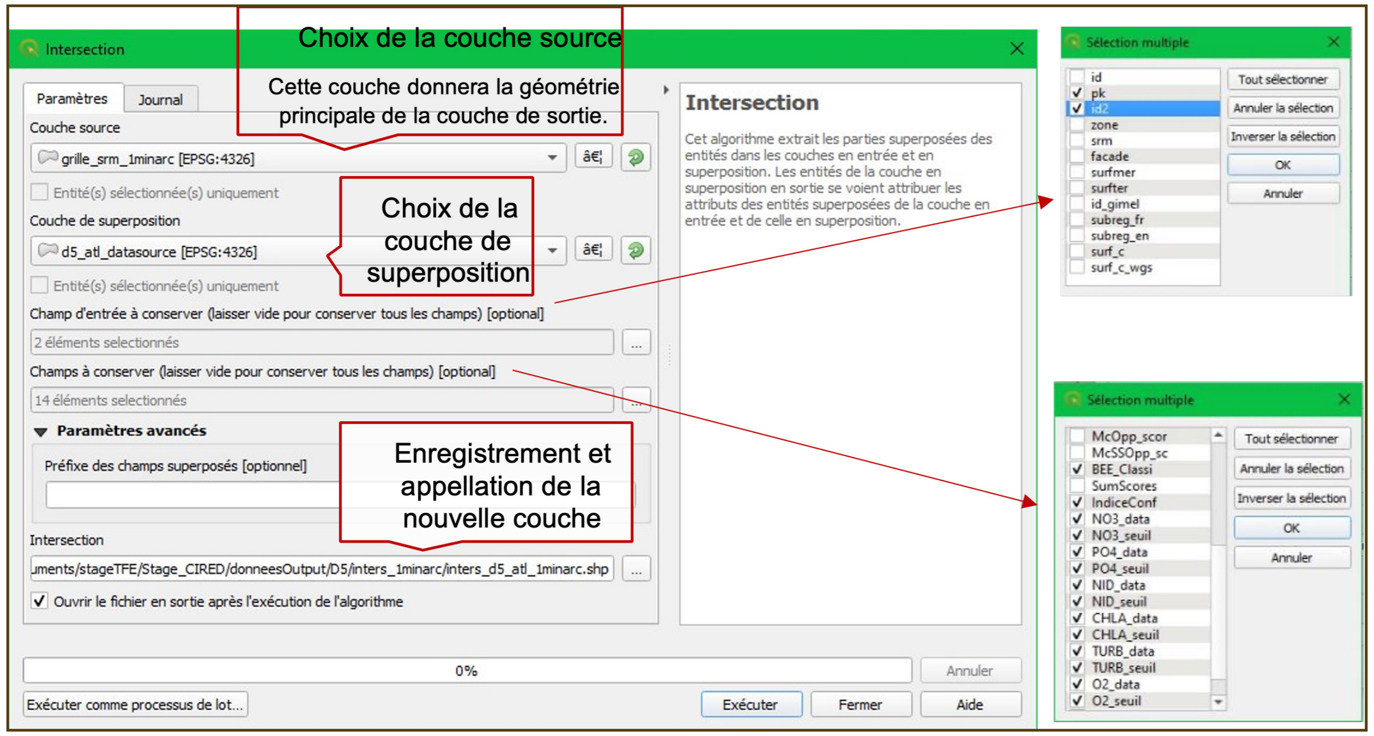



**Figure 2 : Fenêtre de l'outil intersection et son cheminement**

## 2. Deuxième étape : Rééchantillonnage

- Aller dans la table d'attribut et ajouter un nouveau champ en cliquant sur « Ouvrir la calculatrice de champ » :
  - Nom du champ : « surf_int »
  - Changer le type en : Nombre décimal (réel) et avec une précision de 6 o Puis dans l'emplacement réservé aux expressions, ajouter : $area
  - > **L'unité sera en degré². Cela n'est pas embêtant car cet attribut sera utilisé pour faire le rapport de deux surfaces. Cependant, il est nécessaire que cette autre surface soit elle aussi en degré².**

- Faire l'étape précédente sur les deux couches, atlantique et méditerranée.
- Puis fusionner inters_d5_ atl et inters_d5_med avec l'outil « fusion ».

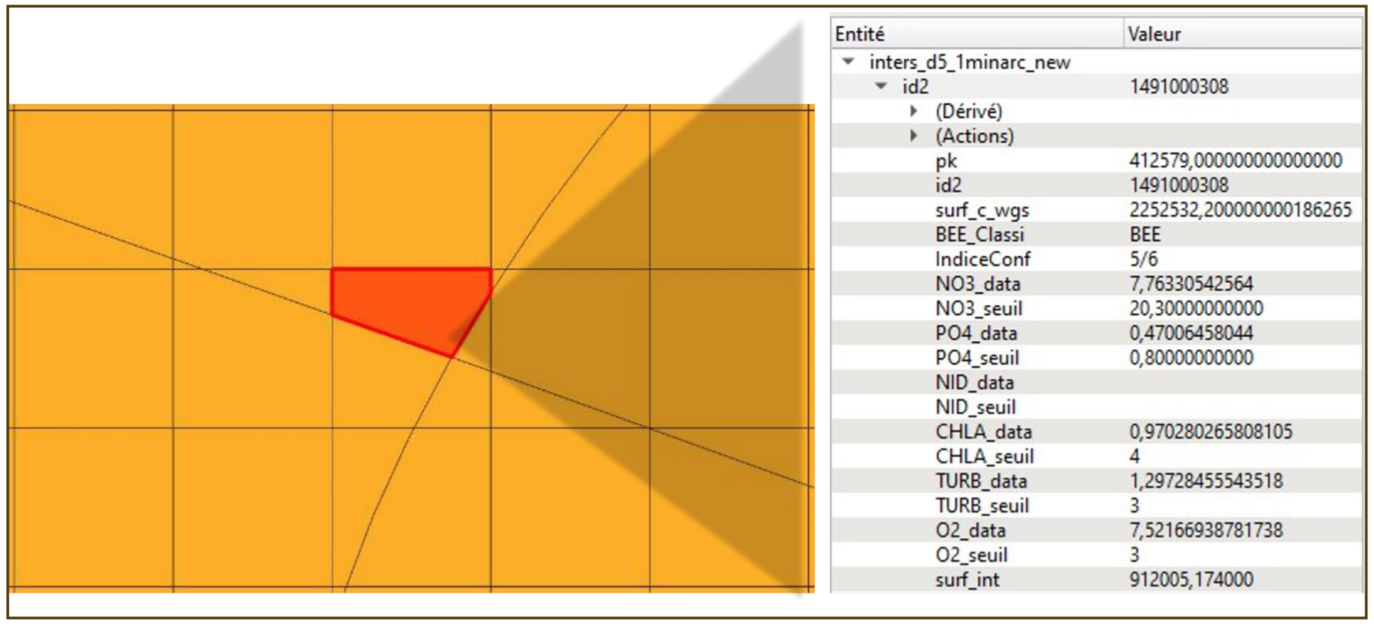



**Figure 3 : Visualisation de la couche de sortie après intersection et de sa table d'attributs.**

**Remarque : La table d'attributs sur une entité donnée peut être observée en faisant un clic droit sur cette icône dans la barre d'outil « Attribut », [icône] , et en cliquant sur une des entités de la couche.**

- Ouvrir « DB Manager » à partir de l'onglet « Base de données » et connectez-vous à la base de données.
- Importer la couche d'intersection complète sur le D5 dans le schéma public.

**Changement d'environnement > pgAdmin 4**

- Ouvrir une page SQL ( = Query Tool) pour débuter la programmation en langage SQL après avoir sélectionné la BDD.

1. Après intersection entre deux couches vecteurs surfaciques, il peut être constater que certaine entité est une surface nulle. Ainsi, il est préférable de les supprimer directement. En effet, ces entités n'apporteront aucun intérêt à notre étude qui se base sur des surfaces observables.

**# Suppression des entités avoisinant le zéro dans le champ « surf_int »**

```
DELETE
FROM inters_d5_1minarc
WHERE surf_int < 0.0001 ;
```

2. Ajout d'un nouveau champ qui correspondra au ratio des surfaces impliquées dans une même cellule.

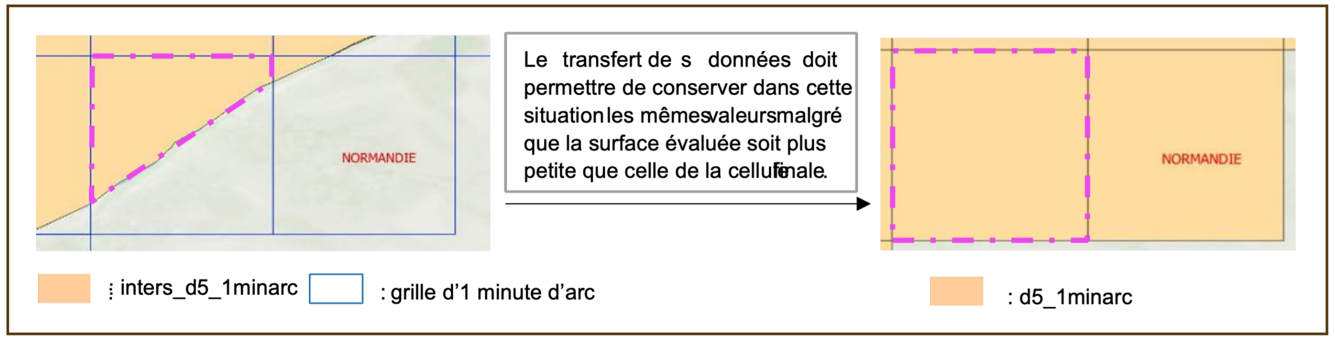
**# Ajout d'un nouvel attribut, nommé ratio_surf**

```
ALTER TABLE inters_d5_1minarc ADD COLUMN ratio_surf REAL ;
```

**# Mise à jour du nouvel attribut**

```
UPDATE inters_d5_1minarc as d
SET ratio_surf = surf_int / sum_tot_pk
FROM (SELECT pk, SUM(surf_int) as sum_tot_pk
FROM inters_d5_1minarc
GROUP BY pk) as i WHERE d.pk = i.pk ;
```

**Remarque liée à un problème rencontré : Au départ, il avait été choisi de diviser la surface intersectée par la surface de la cellule, « Surf_c ». Cependant, il a été aperçu que les valeurs calculées au niveau de la limite mer et terre étaient fausses. En effet, la partie terrestre de la cellule était prise en compte alors que les valeurs ont été évaluées que dans la mer.**




**Solution : Il a été décidé de sommer toutes les surfaces intersectées dans une même cellule pour effectuer le rapport de surface.**



3. **Calcul de la moyenne pondérée de chaque cellule.**

**# Ajout de nouveaux champs intermédiaires**

```
ALTER TABLE inters_d5_1minarc
ADD COLUMN no3  REAL,
ADD COLUMN po4  REAL,
ADD COLUMN nid  REAL,
ADD COLUMN chla  REAL,
ADD COLUMN turb  REAL, ADD COLUMN o2  REAL;
```

```
UPDATE inters_d5_1minarc
SET  no3 = (ratio_surf*no3_data),  po4 =
(ratio_surf*po4_data),  nid =
(ratio_surf*to_number(nid_data, '99.999')),
chla = (ratio_surf*CAST(replace(chla_data, ',','.') as numeric)), -- changement de type de donnée
turb = (ratio_surf*CAST(replace(turb_data, ',','.') as numeric)),  o2 =
(ratio_surf*CAST(replace(o2_data, ',','.') as numeric));
```

**# Somme des valeurs intermédiaires contenues dans une même cellule**

```
CREATE TABLE d5_1minarc
AS SELECT i.pk, i.id2,
sum(i.no3) as no3,
sum(i.po4) as po4,
sum(i.nid) as nid,
sum(i.chla) as chla,
sum(i.turb) as turb,
sum(i.o2) as o2,
g.geom
FROM public.inters_d5_1minarc as i , ecosysacc_1vers.grille as g
WHERE i.pk = g.pk
GROUP BY i.pk, i.id2,
g.geom ;
```

**# Somme des valeurs intermédiaires contenues dans une même cellule mais en prenant en compte le bon état écologique qui a été fixé dans la donnée source. Table utilisée postérieurement.**

```
CREATE TABLE d5_1minarc_ancien_bee
AS SELECT i.pk, i.id2, i.bee_classi,
sum(i.no3) as no3,
sum(i.po4) as po4,£
sum(i.nid) as nid,
sum(i.chla) as chla,
sum(i.turb) as turb,
sum(i.o2) as o2,  g.geom
FROM public.inters_d5_1minarc as i , ecosysacc_1vers.grille as g
WHERE i.pk = g.pk
GROUP BY i.pk, i.id2 ,i.bee_classi, g.geom;
```

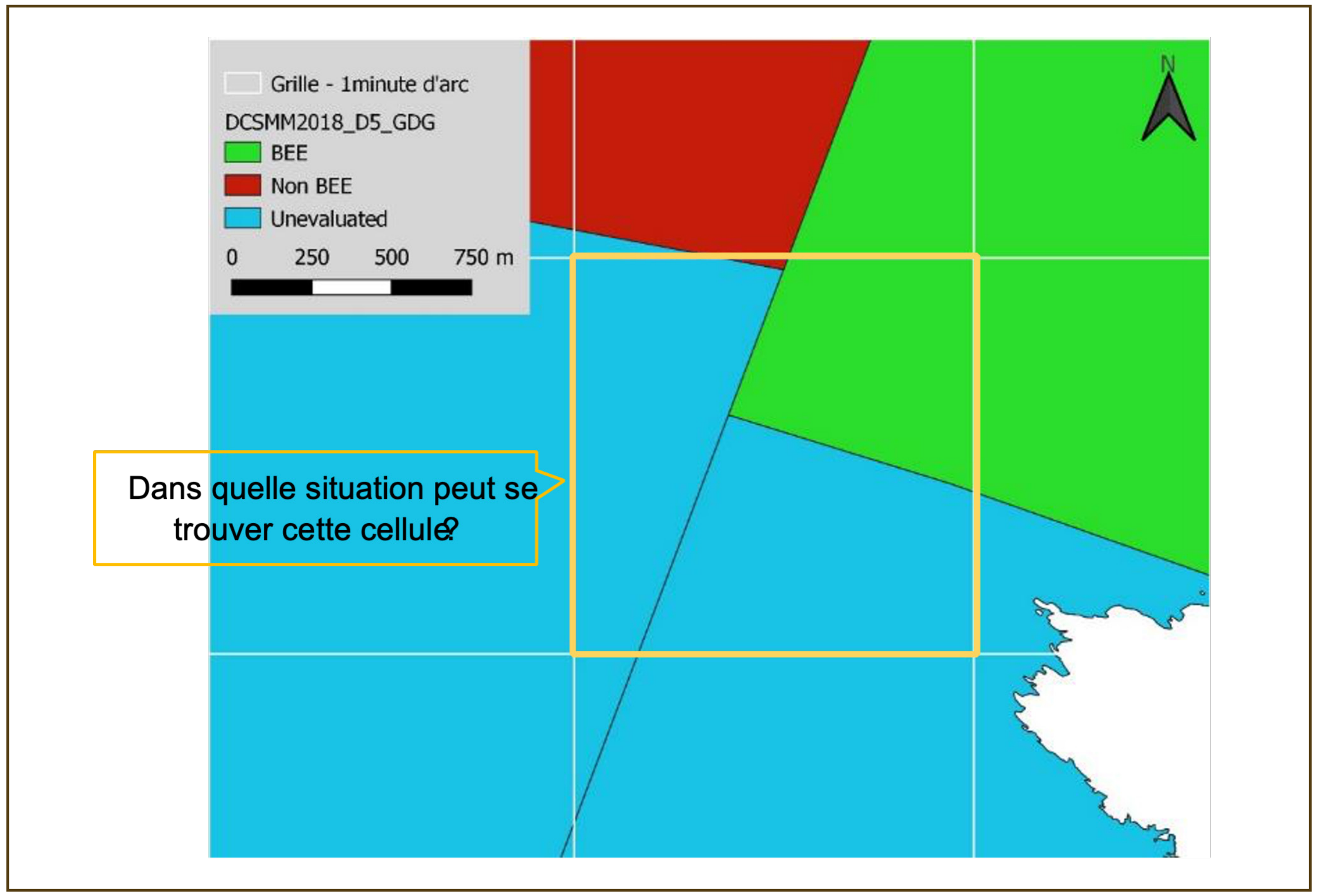
4. **Mise en place de la table qui contiendra les valeurs finales du descripteur 5**

**# Nouvelle table représentant la table finale du descripteur 5 avant mise à jour sur le BEE. De plus, fixation du nombre de cellules selon la grille de référence par utilisation d'une jointure gauche. Cela permet d'avoir un nombre identique de cellules dans la table d5 et la table grille.**

```
CREATE TABLE ecosysacc_1vers.d5_final
AS SELECT p.pk, p.id2, p.geom, e.no3, e.po4, e.nid, e.chla, e.turb, e.o2
FROM ecosysacc_1vers.grille as p
LEFT JOIN d5_1minarc as e
ON p.pk = e.pk
```

## 3. 3ème étape : Mise à jour de la donnée finale

La raison de cette troisième partie est causée à la suite de l'intersection. La question qui en découle est :




**1.** Ajout de deux nouveaux champs qui disposeront de la situation du bon état écologique et de la situation fiable des valeurs présentes dans les cellules.

**# Ajout d'un nouveau champ collectant la situation du bon état écologique de la cellule. Quatre possibilités de valeur :**

- **'BEE'**
- **'Non BEE'**
- **'Unevaluated'**
- **'BEE à réévaluer'**

**ALTER TABLE** ecosysacc_1vers.d5_final
**ADD COLUMN** bee_classi **VARCHAR** DEFAULT 'BEE à réévaluer' ; -- valeur par défaut

**#Ajout d'un nouveau champ collectant la situation des nouvelles valeurs liées à chaque paramètre de l'eutrophisation :**

- **'cohérent'**
- **'A évaluer'**
- **'A réévaluer'**

**ALTER TABLE** ecosysacc.d5_final
**ADD COLUMN** val_echant **VARCHAR** DEFAULT 'cohérente' ; -- valeur par défaut

43 Pourquoi le terme fiable est utilisé ? Cela est dû à la confiance du résultat ayant été obtenu après rééchantillonnage des valeurs de chaque critère. Une colonne est dédiée à cette fiabilité en raison de l'intersection entre des zone évaluées et non-évaluées.



**2.** Diverses mises à jour de la table

**# Changement de la valeur du champ « bee_classi » pour les entités considérées comme inchangées même après le transfert.**

**UPDATE** ecosysacc_1vers.d5_final as
**w SET** bee_classi = d.bee_classi

## Méthode Risque d'effet des pressions sur les habitats

### Descripteur 6

PostgreSQL (pgAdmin4)

Solène Legrand

**> Données sources : Projet CarpeDiem**

- Récupération des scores de sensibilité de la couche « gr_hab_carp_v11_2019.shp » et importation dans la nouvelle table « score_sensibilite », schéma public de la BDD.
- Dans le schéma « ecosysacc_1vers », la table « habitats » met à disposition les habitats fixés au niveau 4 du code EUNIS.
- Dans le schéma « ecosysacc_1vers », la table « pressions_physiques » met à disposition l'intensité des pressions dans chaque maille et qui a été préalablement recueillie dans « refc_plateau_20190409_synthese_pressions_physiques.shp » du projet

**CarpeDiem > Traitement**

## 1ère méthode :
## Prise en compte de l'habitat majoritaire en lui dédiant la cellule entière

### 1. Récupération des habitats majoritaires

**Sélectionner l'habitat majoritaire dans chaque cellule de la grille selon la surface des habitats.**

```
CREATE TABLE public.habitats_maj
AS SELECT h1.pk, h1.id2, habi_niv4, h1.surfhab_pc_niv4, h1.geom
FROM ecosysacc_1vers.habitats  as h1,
    (SELECT pk, MAX(surfhab_pc_niv4) as maxsurf
    FROM ecosysacc_1vers.habitats
    GROUP BY pk ) as m – Récupération des surfaces maximales pour chaque cellule
WHERE h1.pk = m.pk AND h1.surfhab_pc_niv4 = m.maxsurf
GROUP BY h1.pk,h1.id2, h1.habi_niv4, h1.surfhab_pc_niv4, h1.geom ;
```

### 2. Mise à jour des scores de sensibilité selon les habitats fixés au niveau 4 du code EUNIS

Ensuite, il a été nécessaire de faire un tri dans la table « score_sensibilite ».

En amenant au maximum tous les habitats au niveau 4 du Code EUNIS, correspondant au niveau le plus précis dans notre étude, certaines cellules vont alors disposer du même habitat avec un score de sensibilité différent, c'est-à-dire :

| Code EUNIS initial | Score de sensibilité, ex pr_p1_2 | Code EUNIS bloqué au niveau 4 | Nouveau score avec option précaution |
|---|---|---|---|
| A5.13 | $Score_{sensibilté} = 4$ | A5.13 | $Score_{sensibilité} = 4$ |
| A5.135 | $Score_{sensibilté} = 0$ | A5.13 | |

Table 1 : Affectation du nouveau score de sensibilité après modification du niveau de précision des habitats en utilisant l'option précaution.

Le choix d'affectation a été repris de la méthode d'affectation des scores de sensibilité mise en place dans le projet Carpédiem (Voir Figure 1).



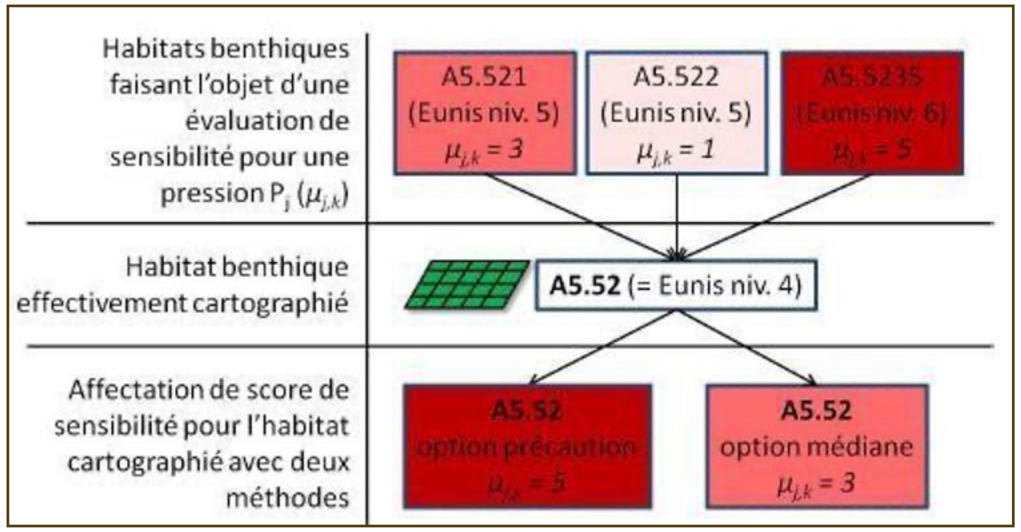



**Figure 1 : Méthode d'affectation des scores de sensibilité selon les deux options, précaution et médiane.**

Ainsi par requête SQL, cela donne :

```
# Pour une pression donnée, prendre en compte uniquement toutes les cellules composées d'un score entre 0 et 5. Puis utilisation de la méthode d'affectation, option précaution, pour l'attribution des scores uniques pour chaque cellule.
CREATE TABLE public.score_sensib_habi_p1_1
AS SELECT h.pk, h.habi_niv4, MAX(s.pr_p1_1_pr) as
pr_p1_1_pr FROM public.score_sensibilite  as s,
ecosysacc_1vers.habitats as hab, public.habitats_maj as h
WHERE h.habi_niv4 = substring(s.cod_eunis from 1 for 5) AND h.id2 = hab.id2 AND s.id2 = h.id2
AND s.pr_p1_1_pr != 99
GROUP BY h.pk, h.habi_niv4 ;
```

**Remarque : les scores égales à 99 correspondent à une absence d'évaluation de la sensibilité de l'habitat par rapport à une pression. Ainsi, il a été choisi de ne pas les prendre en considération dans les calculs car cela engendrerait des erreurs comme par exemple :**

| Code EUNIS initial | Score de sensibilité, ex pr_p1_2 | Code EUNIS bloqué au niveau 4 | Nouveau score avec option précaution |
|---|---|---|---|
| A5.13 | $Score_{sensibilté} = 4$ | A5.13 | $Score_{sensibilité} = 4$ |
| A5.135 | $Score_{sensibilté} = 0$ | A5.13 | |

Table 2 : Affectation du nouveau score de sensibilité après modification du niveau de précision des habitats en utilisant l'option précaution.

Or dans ce cas précis, la sensibilité deviendrait comme inconnue alors que dans l'un des deux cas nous avions un score de 2 équivalent à une sensibilité « Faible ».

### 3. Calcul du risque d'effet pour l'habitat majoritaire

Puis le but est d'observer le risque d'effet pour chaque habitat majoritaire selon une pression donnée. Ainsi il a été choisi d'utiliser la formule sur le risque d'effet (Voir le rapport méthodologique du projet Carpédiem p.44), où ce risque d'effet de la pression, exemple pr_p1_1, sur l'habitat majoritaire de la cellule vaut :

$REF\_ P_{pr\_p1\_1}E_{habimaj} = P_{pr\_p1\_1} \times \mu_{pr\_p1\_1\_pr,habimaj}$

, où $REF\_ P_{pr\_p1\_1}\ E_{habimaj} = REX\_ P_{pr\_p1\_1}\ E_{habimaj} \times \mu_{j,k}$ et

$REX\_P_{pr\_p1\_1}\ E_{habimaj} = P_{pr\_p1\_1} \times 1 = P_{pr\_p1\_1} \times Surf_{habi\_maj\_norm}$ car pour rappel, l'habitat est unique dans chaque cellule.

```
# Calcul du risque d'effet d'une unique pression sur un habitat donné

CREATE TABLE public.risque_effet_par_habitat_pr_p1_1
AS SELECT p.geom, s.pk, s.habi_niv4, ROUND(p.pr_p1_1_lo * s.pr_p1_1_pr, 6) as risq_effet_pr_p1_1
FROM ecosysacc_1vers.pressions_physiques as p, public.score_sensib_habi_p1_1
as s  WHERE p.pk = s.pk;
```

**4. Calcul du risque d'effet concomitant pour l'habitat majoritaire**

Pour finir, l'objectif principal est d'agréger les risques d'effet selon un habitat donné par rapport aux Sous-Régions Marines françaises et à la Zone Economique Exclusive.

```
# Agrégation des risques d'effet pour une unique pression selon les habitats majoritaires par
rapport aux SRM.

CREATE VIEW public.risq_effet_pression_p1_1
AS SELECT g.subreg_fr, r.habi_niv4,
AVG(p1.risq_effet_pr_p1_1) as moy_risq_effet_pr_p1_1 , PERCENTILE_CONT(0.5)
WITHIN – acquisition de la moyenne et de la médiane du risque d'effet de la pression pr_p1_1
GROUP(ORDER BY p1.risq_effet_pr_p1_1) as med_risq_effet_pr_p1_1
FROM public.risque_expo_par_habitat_pression as r, ecosysacc_1vers.grille as g, public.risque_
effet_par_habitat_pr_p1_1 as p1
WHERE g.pk = r.pk AND g.pk = p1.pk
GROUP BY g.subreg_fr, r.habi_niv4
ORDER BY g.subreg_fr, r.habi_niv4 ;
```

```
# Agrégation de tous les risques d'effet dans une unique table

CREATE TABLE ecosysacc.risq_effet_all_pression AS
SELECT g.geom, g.pk , g.id2,
t1.risq_effet_pr_p1_1,
t2.risq_effet_pr_p1_2,
t3.risq_effet_pr_p1_3,
t4.risq_effet_pr_p1_4,
t5.risq_effet_pr_p1_5,
t6.risq_effet_pr_p1_6,
t7.risq_effet_pr_p1_7,
t8.risq_effet_pr_p1_8,
t9.risq_effet_pr_p2_1,
t10.risq_effet_pr_p2_2,
t11.risq_effet_pr_p3_1,
t12.risq_effet_pr_p3_2
FROM ecosysacc_1vers.grille as g
FULL OUTER JOIN risque_effet_par_habitat_pr_p1_1 as t1 ON g.pk = t1.pk
FULL OUTER JOIN risque_effet_par_habitat_pr_p1_2 as t2 ON g.pk = t2.pk
FULL OUTER JOIN risque_effet_par_habitat_pr_p1_3 as t3 ON g.pk = t3.pk
FULL OUTER JOIN  risque_effet_par_habitat_pr_p1_4 as t4 ON g.pk = t4.pk
FULL OUTER JOIN  risque_effet_par_habitat_pr_p1_5 as t5 ON g.pk = t5.pk
FULL OUTER JOIN  risque_effet_par_habitat_pr_p1_6 as t6 ON g.pk = t6.pk
FULL OUTER JOIN  risque_effet_par_habitat_pr_p1_7 as t7 ON g.pk = t7.pk
FULL OUTER JOIN  risque_effet_par_habitat_pr_p1_8 as t8 ON g.pk = t8.pk
FULL OUTER JOIN  risque_effet_par_habitat_pr_p2_1 as t9 ON g.pk = t9.pk
FULL OUTER JOIN  risque_effet_par_habitat_pr_p2_2 as t10 ON g.pk = t10.pk
FULL OUTER JOIN  risque_effet_par_habitat_pr_p3_1 as t11 ON g.pk = t11.pk
FULL OUTER JOIN  risque_effet_par_habitat_pr_p3_2 as t12 ON g.pk = t12.pk ;
```

```
# Ajout de la nouvelle colonne recueillant les valeurs de risques concomitants pour chaque cellule.

ALTER TABLE ecosysacc.risq_effet_all_pression
ADD COLUMN risq_concomitant REAL ;
```



```
# Somme des risques d'effet et s'il y a au moins un risque qui est différent de « null » alors on prend
sa valeur comme risque concomitant et toutes les risques d'effet « null » sont changés en 0.

UPDATE ecosysacc.risq_effet_all_pression
SET risq_concomitant = COALESCE(risq_effet_pr_p1_1,0) + COALESCE(risq_effet_pr_p1_2,0) +
COALESCE(risq_effet_pr_p1_3,0) + COALESCE(risq_effet_pr_p1_4,0) +
COALESCE(risq_effet_pr_p1_5,0) + COALESCE(risq_effet_pr_p1_6,0) +
COALESCE(risq_effet_pr_p1_7,0) + COALESCE(risq_effet_pr_p1_8,0) +
COALESCE(risq_effet_pr_p2_1,0) + COALESCE(risq_effet_pr_p2_2,0) +
COALESCE(risq_effet_pr_p3_1,0) + COALESCE(risq_effet_pr_p3_2,0) ;
```

```
# Si tous les risques d'effet valent « null » alors le risque concomitant est égal à 99

UPDATE ecosysacc.risq_effet_all_pression
SET risq_concomitant = 99
WHERE risq_effet_pr_p1_1 IS NULL
AND risq_effet_pr_p1_2 IS NULL
AND risq_effet_pr_p1_3 IS NULL
AND risq_effet_pr_p1_4 IS NULL
AND risq_effet_pr_p1_5 IS NULL
AND risq_effet_pr_p1_6 IS NULL
AND risq_effet_pr_p1_7 IS NULL
AND risq_effet_pr_p1_8 IS NULL
AND risq_effet_pr_p2_1 IS NULL
AND risq_effet_pr_p2_2 IS NULL
AND risq_effet_pr_p3_1 IS NULL
AND risq_effet_pr_p3_2 IS NULL;
```

# Annex D: Bird species list used in CarpeDiem

| OISEAUX | | | |
|---|---|---|---|
| Famille | Groupe ou espèces | Nom latin | Espèces associées |
| Alcidés | Alcidés | *Fratercula arctica* | Macareux moine |
| | | *Uria aalge* | Guillemot de Troil |
| | | *Alca torda* | Pingouin torda |
| Phalacrocoracidae | Cormorans | *Phalacrocorax carbo* | Grand cormoran |
| | | *Phalacrocorax aristotelis* | Cormoran huppé |
| Sulidae | Fou de Bassan | *Morus bassanus* | - |
| Procellariidae | Fulmar boréal | *Fulmarus glacialis* | - |
| | Petits puffins | *Puffinus puffinus* | Puffin des anglais |
| | | *Puffinus yelkouan* | Puffin yelkouan |
| | | *Puffinus mauretanicus* | Puffin des Baléares |
| | Grands puffins | *Puffinus gravis* | Puffin majeur |
| | | *Puffinus griseus* | Puffin fuligineux |
| | | *Calonectris diomedea* | Puffin cendré |
| Laridae | Grand goéland gris | *Larus argentatus* | Goéland argenté |
| | | *Larus michahellis* | Goéland leucophée |
| | Grand goéland noir | *Larus marinus* | Goéland marin |
| | | *Larus fuscus* | Goéland brun |
| | Sternes | *Sterna paradisaea* | Sterne arctique |
| | | *Sterna hirundo* | Sterne pierregarin |
| | | *Sterna albifrons* | Sterne naine |
| | | *Thalasseus sandvicensis* | Sterne caugek |
| | Mouettes | *Larus ridibundus* | Mouette rieuse |
| | | *Larus melanocephalus* | Mouette mélanocéphale |
| | Mouette pigmée | *Larus minutus* | - |
| | Mouette tridactyle | *Rissa tridactyla* | - |
| Hydrobatidae | Océanites | *Hydrobates pelagicus* | Océanite tempête |
| | | *Hydrobates leucorhous* | Océanite culblanc |
| | | *Hydrobates castro* | Océanite de Castro |
| Stercorariidae | Grand labbe | *Catharacta skua* | - |
| Anatidae | Macreuses | *Melanitta nigra* | Macreuse noire |
| | | *Melanitta fusca* | Macreuse brune |
| Gavidae | Plongeons | *Gavia stellata* | Plongeon catmarin |
| | | *Gavia arctica* | Plongeon arctique |
| | | *Gavia immer* | Plongeon imbrin |

# Marine Mammals species list used in CarpeDiem

| CETACES | | | |
|---|---|---|---|
| Famille | Groupe ou espèces | | Espèces associées |
| Sous-famille Globicephalinae | Globicéphalinés | *Globicephala melas* | Globicéphale noir |
| | | *Grampus griseus* | Dauphin de Risso |
| Sous -famille Delphininae | Petits delphininés | *Delphinus delphis* | Dauphin commun |
| | | *Stenella coeruleoalba* | Dauphin bleu et blanc |
| | Grand dauphin | *Tursiops truncatus* | - |
| Phocoenidae | Marsouin commun | *Phocoena phocoena* | - |
| Balenopteridae | Rorqual commun | *Balaenoptera physalus* | - |
| Physeteridae | Cachalot macrocéphale | *Physeter macrocephalus* | - |



# Annex G: Preliminary analysis on possible reference levels for each dimension of ecosystem condition.

In white, MSFD and other related European directives. In grey, other possibilities to find reference conditions.

**Table 16. Possible sources for reference levels**

| Condition category | Objective | Description of data | Regulation/plan it refers to | Spatial characteristic | Accessibility | Descriptor MSFD |
|---|---|---|---|---|---|---|
| Heritage | Good conservation status of habitats determined to be of Community interest. | ? | Habitat directive (92/43/CEE) | Natura 2000 zones | ? | D1, D6 |
| Heritage | Good ecological status for marine mammals | Thresholds in abundance, level of capture, distribution, stranding | MSFD, OSPAR directive 92/43/CEE | OSPAR (MMN and MC) | SEXTANT | D1 |
| Heritage | Good ecological status for fish and cephalopods | Trend in density of fish species, existence of line break | MSFD | France | SEXTANT | D1 |
| Function | Good ecological status for non-endemic species | Declining number of introduced species | MSFD and OSPAR | - | Not enough data yet | D2 |
| Capacity | Good ecological status of fish stocks | Fish mortality and biomass of mature fish compared to MSY | MSFD, CFP | France | Ifremer SIH | D3 |
| Function | Good ecological status contaminants | ERL, EAC, EC, or trends depending on indicator | MSFD, European Comission | France, mix of spatial and stations | Quadrige | D8 |
| Function | Good ecological status sanitary questions | Thresholds for concentrations of 11 indicators | MSFD, European Comission ((CE) n° 1881/2006) | ? | Quadrige | D9 |
| Function | Good ecological status eutrophication | for concentration of 6 indicators (nutriments, chlorophyll a, photic value, toxic algae,..) | MSFD, OSPAR, WFD | ? | ? | D5 |
| Function | Good ecological status of marine debris | Significative decreasing trend of marine debris (#/km²) | MSFD | France | SEXTANT | D10 |
| Heritage | No net loss of biodiversity | | Lois pour la reconquête de la biodiversité | | | D1 |
| Function | Art. L. 411-5.-I.-Est interdite l'introduction dans le milieu naturel, qu'elle soit volontaire, par négligence ou par imprudence, susceptible de porter préjudice aux milieux naturels, aux usages qui leur sont associés ou à la faune et à la flore sauvages | | Lois pour la reconquête de la biodiversité | | | D2 |
| Heritage | Art 113 1° D'élaborer et de mettre en oeuvre un programme d'actions territorialisé de protection de 55 000 hectares de mangroves d'ici à 2020 | | Lois pour la reconquête de la biodiversité | | | D1 |
| Heritage | 20% ZEE protégée en 2020 | | Stratégie nationale pour la biodiversité | | | D1 |
| Heritage | Protection en mer de 100 % des récifs coralliens français à horizon 2025, avec un objectif intermédiaire de 75 % en 2021 | | Plan biodiversité | | | D1 |
| Capacity | Establishment of recreational sea fishing management | Minimal size for capture and good practices, but no thresholds | Charter for the sustainable recreational fishing | | | D3 |

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