



Defining ecoregions of the Mediterranean Sea

May 2015

Mapping areas at high risk of environmental disturbance

Ecoregions: Objectives

Recent changes in environmental factors that regulate marine ecosystems have resulted in drastic changes in the biogeochemical functioning of the oceans. This in turn has resulted in changes to marine habitats, affecting the distribution and dynamics of marine species. In recent years, increasing marine observations together with growing demands for effective ecosystem based management have allowed us to characterize the present state of marine ecosystems, which is necessary to predict future changes in these ecosystems.

Goals

An ecological geographical framework based on environmental and biological data is required for:

- ✳ Identifying and monitoring key marine ecosystems
- ✳ Conservation and ecosystem management
- ✳ Implementation of scientific cruises and ecological studies

PERSEUS has introduced a new approach, known as ecoregionalisation, for characterizing the present state of marine ecosystems. Ecoregionalisation can be defined as “the process and output of identifying and mapping broad spatial patterns based on physical and biological attributes through classification methods used for planning and management purposes”. Ecoregions are unique macro-assemblages of flora, fauna and the supporting geophysical environment contained within distinct but dynamic spatial boundaries. Such ecological partitioning helps us to better understand biogeochemical or ecological processes at regional scale, providing a framework for ecosystem management.

Ecoregions: Outcomes

PERSEUS has provided an ecological geographical framework characterizing the main species assemblages and environmental features, and quantifying the various environmental and human factors at play in the Mediterranean Sea by:

- ✳ partitioning the Mediterranean Sea into three-dimensional **biogeochemical regions** according to environmental characteristics
- ✳ partitioning the Mediterranean Sea into **26 ecoregions** based on the identification of main biological assemblages
- ✳ quantifying the **impact of human pressures** for each of the ecoregions and including this into the spatial analysis to identify the systems most at risk.

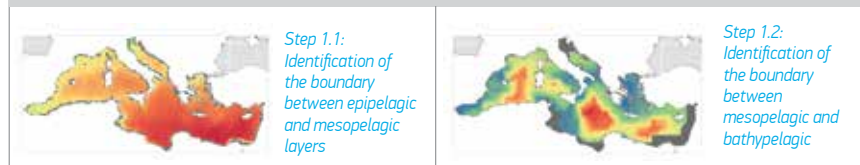
This ecoregionalisation approach provides tools for biodiversity and ecosystem-based fisheries management, especially for the on-going implementation of the EU's Marine Strategy Framework Directive (MSFD). The regions facing the highest risks of environmental disturbance have been identified and mapped, and now require adapted conservation strategies to ensure the sustainability of marine ecosystems.

Task 1: Identify biogeochemical regions

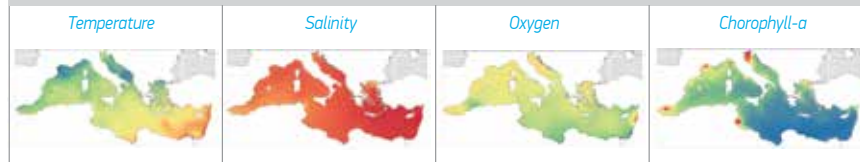
PERSEUS divided the open-sea and seafloor of the Mediterranean Sea into biogeochemical regions. These regions are similar to the biogeochemical provinces described by Longhurst (2007) but forced by mesoscale environmental features. Our approach was to (1) identify the vertical limits of each open-sea layer; (2) summarise the environmental characteristics of each layer over several years; (3) identify the most defining environmental conditions in each layer; and (4) cluster points into regions with similar characteristics and identify the strength of the regions' boundaries.

Figure 1: Key steps to create biochemical regions

Step 1: Identify the vertical limits of each open-sea layer



Step 2: Summarise the environmental characteristics of each layer over several years

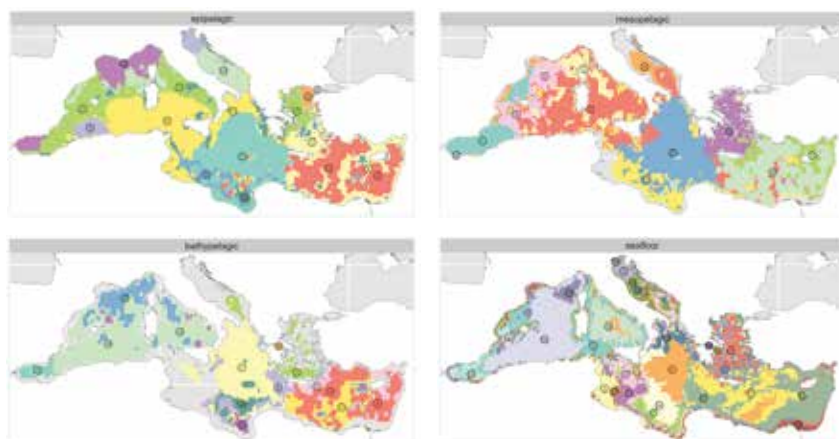


Step 3: Identification of the main environmental parameters of each pelagic layer and the seafloor

Step 4: Clustering analysis for each pelagic layer and the seafloor: K-means, C-means, Agglomerative Complete Linkage and Agglomerative Ward's Linkage; identification of the number of clusters to consider; and quantification of the effectiveness of the horizontal boundaries

Each biogeochemical region can be considered as a potential habitat where adapted species can maintain their populations.

Figure 2: Bioregions



Task 2: Identify Mediterranean marine ecosystems

Main Objectives: To identify and characterize the main biological assemblages for all trophic levels by:

- ✳ gathering data on the presence of as many Mediterranean species as possible
- ✳ computing a habitat suitability index for each species
- ✳ evaluating the diversity and community structure at each trophic level
- ✳ combining biogeochemical and eco-regionalisation data to determine an ecological geography

Based on the spatial distributions of the communities at each trophic level and of environmental variables, PERSEUS delineated 26 marine ecosystems (or ecoregions) in the Mediterranean Sea. Each ecoregion detected here represents a characteristic species association from primary producers to top predators, forced by similar environmental conditions. The map highlights that biological communities further divide biogeochemical regions, meaning that fine differences in environmental conditions influence ecosystem structure.

Figure 3: 26 marine ecoregions



Conclusions

PERSEUS mapped the ecoregions with the highest risk of environmental disturbance, namely: Algero-Tunisian coast (14), the Adriatic Sea (21), the Aegean Sea (5), the Gulf of Gabes (16), the Catalan coasts (10), the Gulf of Lions (3) and the Egyptian coasts (26).

These ecoregions are somewhat homogenous in community composition and environmental conditions and therefore, would be appropriate management units for spatial management at regional scale. They often cross political boundaries highlighting the need for intergovernmental cooperation.

This work also showed that gathering data at basin scale, over the Mediterranean, is very difficult, in particular in the case of biological data. Some regions are very scarcely explored (the south eastern basin in particular), lower trophic levels are poorly described, most data is not in readily accessible databases and not willingly shared. The main limitation of this work is the data it rests on; more data, of all kinds, would surely improve it. This calls for an international effort, to which PERSEUS contributes, to make already collected data accessible to all and to target new collection efforts towards data poor regions.

Task 3: Identify human dimensions

Several measures of human impacts on marine ecosystems (Halpern et al 2008) were averaged for each of the 26 ecoregions identified above. Three groups of pressures were separated: climate change; fisheries; pollution. All regions are affected by at least one kind of pressure. Some regions cumulate strong pressures of all kinds.

Figure 4: Human pressures in the ecoregions

