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Towards the Identification and Reference List of Pelagic Habitat Types in the Mediterranean Sea

Delegates are kindly requested to bring their documents to the meeting

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1. Summary

Our understanding of the structural and functional properties of the Mediterranean pelagic realm is still very poor, because of the several difficulties inherent in the investigation of the open ocean environment. Such weakness presents significant challenges for ocean resource management and conservation planning: without knowledge of the distribution of the elements of marine biodiversity, the associated environmental factors, and an agreed-upon framework for classification of habitats, it is difficult to assess how well our conservation efforts have achieved representation of biodiversity, and conversely to understand the negative impacts of human activities on the marine environment.

Since a classification of pelagic habitat types will assist efforts to implement much-needed ecosystem-based management in open and deep seas, such classification was attempted before for many of the world's marine regions, and by many agencies. A sample of these is succinctly described in this document, including: a discussion of pelagic habitat types contained in an effort of compiling biogeographical classification for global open ocean and deep sea areas, named "GOODS"; a classification of oceanographic features relevant to the designation of EBSAs in the open seas; the classification of pelagic water column habitat types provided for in the *European Nature Information System*, EUNIS; a subdivision of water column habitats contained in guidelines for reporting under the *Marine Strategy Framework Directive*; and finally, a simplified pelagic habitat classification, tailored on the Mediterranean, based on the level of primary productivity in the euphotic layer (J.-N. Druon, JRC, pers. comm.).

The impetus for the preparation of a reference list of pelagic habitats in the Mediterranean also derives from the a requirement connected with the implementation of the Ecosystem Approach (EcAp) roadmap. All Mediterranean species belonging to the species groups selected to be addressed in relation to Ecological Objective 1 (i.e., marine mammals, birds and reptiles) are, to a great extent, depending from the status of their habitats in the pelagic realm; therefore, disposing of a reference list of pelagic habitat types that are necessary to the good conservation status of such species – at least of those represented in the Mediterranean region by regular populations - is of fundamental importance. A few ecological properties of these species (e.g., the predominant importance of the upper portion of the pelagic realm, as well as the influence exerted by low trophic level prey distributions affected by primary productivity) may serve to simplify the task.

For the above reasons, a first attempt at classifying pelagic habitats in the Mediterranean, which is also relevant for the species groups addressed by the EcAp process, could involve placing an emphasis on the distribution of primary productivity in the epipelagic layer (0 – 200 m); a proposal to this effect is presented here. Proposing a reference list of pelagic habitats in the mesopelagic, bathypelagic and abyssopelagic layers (200 – 6,000 m) is far more challenging, but fortunately less relevant for the regular species from the groups selected for the EcAp process. Although many cetaceans dive to mesopelagic waters, and

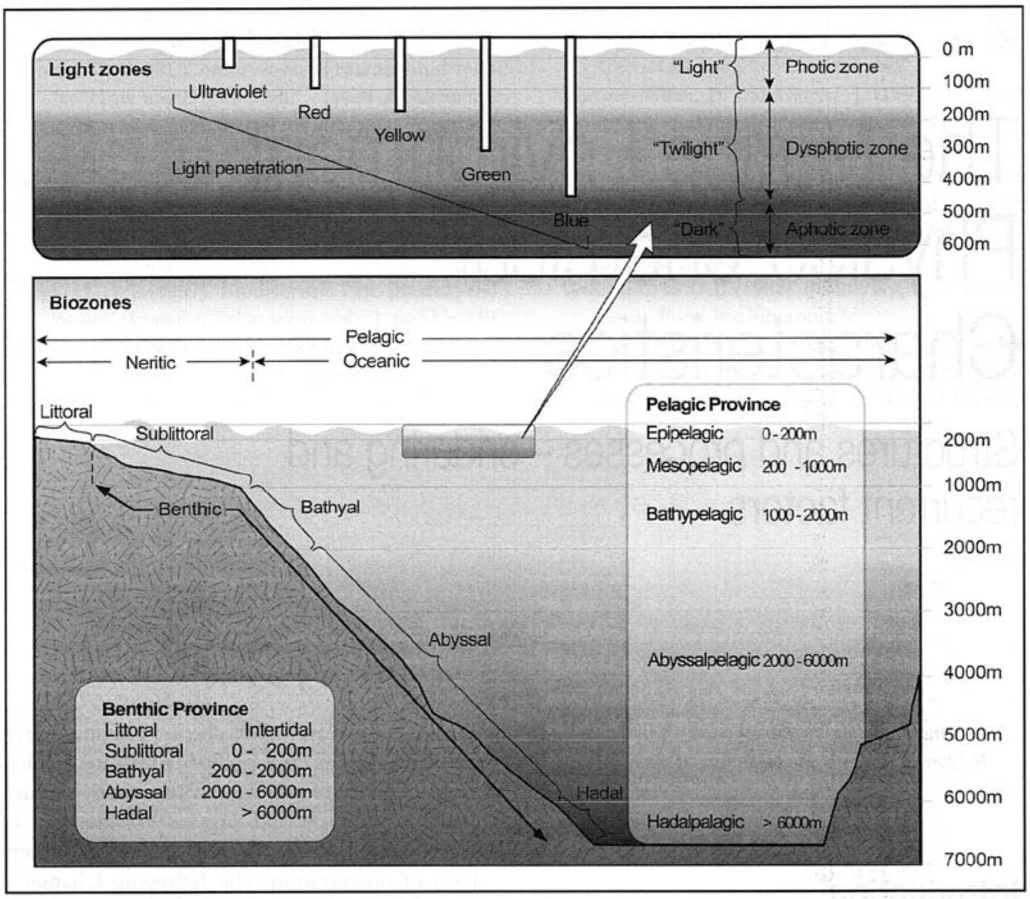
some even beyond, these dives are performed in search of food, and the animals are forced to return to the surface in a range of 10s-100s of minutes after the beginning of their dives.
Clearly, identifying and classifying pelagic habitat types beyond the epipelagic layer is a complex task requiring a good understanding of the interplay between abiotic (i.e., depth, temperature, salinity and currents) and biotic factors, and of the time and space scales involved in such interplay. As a consequence, it is recommended that this effort be achieved through in-depth multidisciplinary expert consultations.

2. Definitions

Considerable lexical confusion exists in the literature concerning the meaning of the word "**pelagic**". Throughout this document, the term "pelagic" refers solely to a **vertical subdivision** of the marine environment (Fig. 1). Based on this concept, "pelagic" indicates one of two major realms (sometimes called "provinces") in which the oceans are vertically subdivided. The **pelagic realm** is the water column and all the organisms that inhabit it, as opposed to the **benthic realm**, which is the sea floor with all the creatures that live within or upon it (Roff & Zacharias 2011).

By contrast, using "pelagic" to define a horizontal subdivision of the oceans - e.g., in contrast to "coastal" - is avoided in this document for sake of clarity. The correct horizontal subdivision of the oceans envisages two zones:

- the *neritic zone* – also known as *coastal zone* - which is the portion of the ocean lying above the continental shelf (i.e., extending from the low tide mark to the location corresponding to the continental shelf break - around a depth of 200 m); and
- the *oceanic zone* – also termed the *open ocean* or *open sea* - which extends away from the coast beyond the shelf break.



Source: Redrawn from various sources

Fig. 1 – Diagram of the pelagic and benthic realms of the marine environment, showing generally recognised vertical depth and light zones (from Roff and Zacharias 2011).

3. Introduction

The pelagic ocean is the largest and least known biome of Planet Earth. This condition is also true if scaled down from the global to the regional dimension, which is the focus of this document. Even within the relatively limited size of the Mediterranean Sea, and in spite of centuries of investigations of the region's geomorphological, oceanographic and ecological features, our understanding of both the structural and functional properties of the Mediterranean pelagic realm remains very poor.

This condition can be explained in many ways. First, pelagic systems are inherently different from terrestrial ecosystems. The distribution of species in the water column is in large part conditioned by the movements of the water masses and by the complex interactions between biological and physical processes – such as the triggering of biomass production caused by the upwelling of deep, nutrient-rich waters into the euphotic layer, where photosynthesis can occur. Physical forcing mediating planktonic growth and retention in the pelagic realm occurs over temporal and spatial scales that are measured in seasons and thousands of kilometres. Bathed in a medium subject to constant flux, critical areas in the pelagic realm continuously shift in space and time, and the water column at any given location can be classified differently at different times of the year.

Second, because of its tri-dimensional nature, acquiring knowledge of the pelagic realm is quite challenging when compared to a similar effort in the benthic realm. Unsurprisingly, marine science has made much greater and faster progress historically in investigations of the sea floor than it has made in the water column, because the benthic realm is simply an underwater extension of the largely bi-dimensional terrestrial landscapes, which humans are more familiar with. The ecological scales and processes operating in the two systems are fundamentally different. The benthic realm is more heterogeneous, less interconnected, with slower rates of dispersal and higher degrees of local endemism; habitat features may be stable for years to centuries, down to scales of meters or less. In contrast, the pelagic realm is dominated by highly dynamic oceanographic processes operating on large spatial scales but relatively shorter time scales; detailed locations of individual pelagic habitat features are predictable only over spatial scales of tens of kilometres or more, and temporally over scales only up to a few weeks (Dunn et al. 2011).

Third, access to and assessment of the pelagic realm is more difficult than anywhere else on Earth; even harder, to some extent, than in outer space. In addition to its seasonal and interannual variability, which causes the boundaries between habitats to be “fuzzy”, the watery medium cannot be easily observed because it is opaque to view (except in the range of tens of metres, in the best conditions of water transparency and lighting). It mostly lies far from land, and even if consisting of a mosaic of habitats that marine species readily react to, such habitats cannot be detected by humans without the assistance of sophisticated technologies.

Such conditions present significant challenges for ocean resource management and conservation planning. And yet, without knowledge of the distribution of the elements of marine biodiversity, the associated environmental factors, and an agreed-upon framework for classification of habitats, it is difficult to assess how well our conservation efforts are achieving representation of biodiversity, and conversely to understand the negative impacts of human activities on the marine environment. A classification of pelagic habitats will assist efforts to implement much-needed ecosystem-based management in open and deep seas (Game et al. 2009), including consideration of dynamic MPA designs to encompass species which use well-defined but spatially dynamic ocean features (Hooker et al. 2011).

All the reasons listed above support the idea that an effort of compiling a reference list of pelagic habitat types in the Mediterranean is necessary. Furthermore, such effort will be a much needed complement to other similar tools prepared by RAC/SPA, such as the reference lists of Mediterranean marine benthic habitats (UNEP-MAP-RAC/SPA 2006).

4. Diversity of Mediterranean pelagic waters

The water masses composing the Mediterranean are influenced by a complex interplay of physical, chemical, biological and anthropogenic factors, which are responsible for their diversity, composition, dynamics, and ability to host living species, and generate a mosaic of different habitats which is at the root of the region's very high levels of marine and coastal biodiversity (Bianchi & Morri 2000).

The diversity of Mediterranean pelagic waters must be considered in view of its overall circulation pattern, which is primarily driven by thermohaline forcing. In extreme synthesis, Atlantic Water (AW) is sucked into the Mediterranean through the Strait of Gibraltar as a result of the strong evaporation occurring over the basin, caused by the climatic and meteorological characteristics of the region. The AW flows along the Mediterranean surface in an easterly direction; as it does so it becomes more saline and denser through evaporation, and eventually sinks to mesopelagic depths to form the Levantine Intermediate Water (LIW). The LIW then flows back westward, sandwiched between the AW on top and the Mediterranean Deep Water below, which is formed during winter when dense and cold water from the north-western Mediterranean, the northern Adriatic and the northern Aegean sinks and accumulates at the bottom. The LIW eventually exits into the Atlantic by overflowing above the Gibraltar sill, under the inflowing AW (for a recent summary, see Würtz 2010).

The circulation pattern described above is, of course, a great oversimplification of what actually happens. Results from palaeoceanographic simulations for the last 20,000 years show that anomalies of atmospheric forcing (i.e., winds) over the basin can cause large-amplitude seasonal and interannual variability of the circulation and water mass structure in the Mediterranean (Pinardi & Masetti 2000). Another aspect further increasing the complexity and stochasticity of Mediterranean circulation involves the formation of quasi permanent gyres along the continental slope, particularly along the North African coastline, due to the Coriolis effect; along-shore currents in these parts of the Mediterranean meander and generate, a few times per year, anticyclonic eddies that can reach diameters of ≥100-200 km, propagate eastward at speeds up to a few km/day, and sometimes extend down to the bottom (2-3000 m). These eddies drift for years (up to 3 at least) in the central part of the basins, possibly coming back shoreward where they interact with their parent current, sometimes in a dramatic way (Millot & Taupier-Letage 2004).

5. Characterisation of habitats of species selected for the "EcAp" Process

The impetus for the preparation of a reference list of pelagic habitats in the Mediterranean not only derives from the need of completing the characterisation of marine and coastal habitats in the Mediterranean, after reference lists of coastal habitats and marine benthic habitats have been completed in the past. Characterising pelagic habitats in the Mediterranean has also become a requirement connected with the implementation of the Ecosystem Approach (EcAp) roadmap, as per decision IG.20/4, "*Implementing MAP ecosystem approach roadmap: Mediterranean Ecological and Operational Objectives, Indicators and Timetable for implementing the ecosystem approach roadmap*" adopted by the Contracting Parties to the Barcelona Convention at their 17th Meeting in Paris in February 2012.

The EcAp roadmap envisages, amongst other things, the development of a set of 7 *Ecological Objectives* corresponding to the Vision and Strategic Goals of the process. Each Ecological Objective will be attained through sets of *Operational Objectives*, with corresponding *Indicators*, *Good Environmental Status* (GES) *Descriptions* for each indicator, and corresponding *Targets*.

Ecological Objective 1 is defined as follows: “Biological diversity is maintained or enhanced. The quality and occurrence of coastal and marine habitats and the distribution and abundance of coastal and marine species are in line with prevailing physiographic, hydrographic, geographic and climatic conditions”.
The box below provides details on the Operational Objectives and Indicators defined to reach Ecological Objective 1.

Ecological objective 1	Operational Objectives	Indicators
Biological diversity is maintained or enhanced. The quality and occurrence of coastal and marine habitats and the distribution and abundance of coastal and marine species are in line with prevailing physiographic, hydrographic, geographic and climatic conditions.	1.1 Species distribution is maintained	1.1.1 distributional range
		1.1.2 Area covered by the species (for sessile/benthic species)
	1.2 Population size of selected species is maintained	1.2.1 population abundance
		1.2.2 population density
	1.3 Population condition of selected species is maintained	1.3.1 population demographics (e.g. body size, age class structure, sex ratio, fecundity rates, survival/mortality rates)
	1.4 Key coastal and marine habitats are not being lost	1.4.1 Potential / observed distributional range of certain coastal and marine habitats listed under SPA protocol
		1.4.2 Distributional pattern of certain coastal and marine habitats listed under SPA protocol
		1.4.3 Condition of the habitat-defining species and communities

The EcAp Coordination Group during its first meeting (Athens, May 2012) recommended that, as far as the Ecological Objective 1 (biodiversity) is concerned, targets be addressed to specific endangered or threatened species, and in particular to **three species groups** (marine mammals, birds and reptiles) selected from the Annex II to the SPA/BD Protocol (see the list of species in the Appendix). By contrast, concerning habitats, the Coordination Group recommended that targets be developed in relation to priority benthic habitats. However, benthic habitats are only indirectly relevant to the pelagic species selected. Hence the need of defining a list of pelagic habitats in the Mediterranean, that achieves representativeness across broad categories of habitat types. In fact, it was established that “The cluster members will have also to identify indicator habitats amongst pelagic habitats such as upwelling areas, fronts and gyres.”[1]

[1] UNEP(DEPI)/MED WG.373/3, Page 5

Specifically, Operational Objective 1.4 ("*key coastal and marine habitats are not being lost*") is connected to three indicators, proposed GES descriptions, and proposed targets, as detailed in the box below:

Indicator	Proposed GES Description	Proposed Targets
1.4.1 Potential/observed distributional range of certain coastal and marine habitats listed under SPA protocol	The habitat is present in all its potential distributional range	*State*: The ratio potential/observed distributional range = 1 *Pressure*: Decrease in the main causes of habitat decline
1.4.2 Distributional pattern of certain coastal and marine habitats listed under SPA protocol	The distributional pattern is in line with prevailing physiographic, hydrographic, geographic and climatic conditions	*State*: Zero net loss of habitat
1.4.3 Condition of the habitat-defining species and communities	The population size and density of the habitat-defining species are at levels ensuring the long-term maintenance of the habitat	*State*: No human-induced decrease in population abundance and density The species shows a positive trend in population abundance and density (for recovering habitats)

At a minimum, classifying the types of pelagic habitats known to be important for the species selected for the EcAp process could provide an indication on where to start from in the wider effort of the construction of a comprehensive reference list of Mediterranean pelagic habitat types.

By way of example, the box below summarizes the current knowledge of the habitat requirements of 12 marine mammal species, listed in Annex II of the SPA/BD Protocol, which are regular in the Mediterranean:

Species	Realm	Zone	Prey
fin whale	pelagic (from epipelagic to mesopelagic)	oceanic and neritic	epipelagic and mesopelagic
short-beaked common dolphin	pelagic (epipelagic)	neritic and oceanic	epipelagic
long-finned pilot whale	pelagic (from epipelagic to mesopelagic)	mostly oceanic	mesopelagic
Risso's dolphin	pelagic (from epipelagic to mesopelagic)	oceanic (slope)	mesopelagic
Mediterranean monk seal	pelagic (epipelagic) and terrestrial	neritic (including caves)	mostly demersal
killer whale	pelagic (epipelagic)	oceanic and neritic	epipelagic, demersal
harbour porpoise	pelagic (epipelagic)	neritic	mostly demersal
sperm whale	pelagic (from epipelagic to abyssopelagic)	oceanic (outer slope)	mesopelagic to abyssopelagic
striped dolphin	pelagic (from epipelagic to mesopelagic)	mostly oceanic	mesopelagic
rough-toothed dolphin	pelagic (epipelagic)	oceanic and neritic	epipelagic
common bottlenose dolphin	pelagic (epipelagic)	neritic	demersal and epipelagic
Cuvier's beaked whale	pelagic (from epipelagic to abyssopelagic)	oceanic (slope, submarine canyons)	mesopelagic to abyssopelagic

The above example testifies to the variety, and vertical and horizontal distribution, of habitat types that are used by the complement of marine mammal species regularly occurring in the Mediterranean Sea. This variety demonstrates the challenge of classifying pelagic habitat types on the basis of combinations of biotic and abiotic characteristics, such as was previously done with benthic habitats, even solely in terms of their relevance to groups of selected species. However, a few ecological properties of these species may serve to simplify the task.

First, the predominant importance of the upper portion of the pelagic realm for all marine mammals should be noted, not surprisingly considering the constant physiological need for atmospheric oxygen of these air-breathing vertebrates. This characteristic is also shared by birds and marine turtles.

Second, species that are in large part or totally conditioned by low trophic level prey distributions affected by primary productivity, which can be remotely measured, have been shown to be predictably found in correspondence of large oceanic fronts, as detected through satellite-derived sea-surface chlorophyll content (chl *a)* and temperature (SST). As an example, Druon et al. (2012) were able to determine the distribution of fin whale feeding habitat in the Mediterranean based on a specific range of surface chl *a* content (0.11 to 0.39 mg m^{-3}) and minimum (92 m) water depth. Those authors calibrated daily maps and evaluated them against independent sets of fin whale sightings, and found that their model performed well, with 80% of the presence data <9.7 km from the predicted potential habitat. Overall, fin whale potential habitat occurred frequently during summer in dynamic areas of the general circulation, and was substantially more spread over the basin in winter.
However, as far as other species are concerned, which are linked to their feeding habitats by the presence of prey species belonging to higher trophic levels, the remotely-observed distribution of high levels of primary productivity may become less reliable as an indicator of habitat, and the task of defining habitats for such species becomes increasingly challenging.

6. Examples of pelagic habitat types classifications

Classifications of pelagic habitat types have been attempted before for many of the world's marine regions and by many agencies. A sample of these is succinctly described here, including: a discussion of pelagic habitat types contained in an effort of compiling biogeographical classification for global open ocean and deep sea areas, named "GOODS" (UNESCO 2009); a classification of oceanographic features relevant to the designation of *Ecologically or Biologically Significant Areas* (EBSAs) in the open seas (Dunn et al. 2011); the classification of pelagic water column habitat types provided for in the *European Nature Information System*, EUNIS (Davies et al. 2004); a subdivision of water column habitats contained in guidelines for reporting under the *Marine Strategy Framework Directive* (European Commission 2012); and finally, a simplified but quite useful pelagic habitat classification, tailored on the Mediterranean, based on the levels of primary productivity in the euphotic layer (J.-N. Druon, JRC, pers. comm.).

6.1. GOODS

“GOODS” is an acronym representing an effort at compiling a biogeographic classification for *global open ocean and deep sea* areas, resulting from a workshop which took place in Mexico City in 2007 under the auspices of the Convention on Biological Diversity (UNESCO 2009). The output of the workshop was intended to support the efforts by the Convention on Biological Diversity (CBD) and the UN *Ad Hoc Open-ended Informal Working Group* to study issues relating to the conservation and sustainable use of marine biological diversity beyond areas of national jurisdiction. Many governments in several policy fora had requested a biogeographic classification to assist in further identifying ways to safeguard marine biodiversity in marine areas beyond national jurisdiction and in support of ocean management measures, including marine protected areas. The proposed biogeographic classification was intended to provide a planning tool to assimilate multiple layers of information and extrapolation of existing data into large “bioregions” or provinces (assemblages of flora, fauna and the supporting environmental factors contained within distinct but dynamic spatial boundaries).

Chapter 5 in UNESCO (2009) is dedicated to pelagic systems, and reviews the overall conceptual approaches (taxonomic and physiognomic) to biogeographic classification systems in the pelagic realm, as well as the major data and information sources available for high seas pelagic communities, habitats and biogeographic classification. The report concluded that the main large-scale physical features which an appropriate system should capture include: a) core areas of gyres, b) equatorial upwelling, c) upwelling zones at basin edges, and d) important transitional areas, such as convergence and divergence areas. Starting with those main physiognomic features, fine-scaled biographic units nested within the large-scale features must also be considered, such as basin-specific boundary current upwelling centres, and core areas of gyres. In the report it was also recalled that the pelagic system contains some features – such as the poorly known deep pelagic biome, hotspots of biodiversity, migratory species, and “fuzzy” boundaries - which present specific challenges for biogeographic classification. With such premises, and on the basis of a Delphic (expert-driven) approach, a world map of pelagic biogeographic classes was provided, including 30 provinces having unique environmental characteristics in regards to variables such as temperature, depth and primary productivity. All such provinces represent subdivision of the major oceans, therefore excluding from the grand scheme regional seas, such as the Mediterranean.

6.2. Classification of oceanographic features relevant to EBSAs in the open seas

Dunn et al. (2011) reported on the results of a workshop convened under the auspices of the CBD to consider how to incorporate the pelagic realm into the EBSA (*Ecologically or Biologically Significant Area*) identification process. During the workshop, in-depth guidelines were developed for specific criteria, and over-arching general guidelines were articulated. The general guidelines and considerations developed by the workshop concern considerations of: **size** (the scale of pelagic features and life-history stages can be 1,000s–

10,000s km^2; delineation of EBSAs must match these scales); **time** (the pelagic ocean is highly dynamic, consideration must be given to how features and organisms move over time); **tri-dimensionality** of the oceans (the average depth of the ocean is ~3,700m, the delineation of pelagic EBSAs should not solely consider surficial elements); **dynamicity** of ocean masses (the use of oceanographic variables that vary over space and time to delineate EBSAs is possible and encouraged); **uncertainty** and **adaptiveness** (given the relative lack of data for the pelagic realm, there is an increased need to build uncertainty into the EBSA identification process. Further, there is a need to ensure the process is adaptive and ongoing so adjustments can be made as new data become available).

Finally, the workshop participants developed a typology of oceanographic features that could meet the EBSA criteria, and provided specific examples of each type. These include: a) pelagic areas over static bathymetric features (continental shelf breaks, seamounts, submarine canyons, areas of high slope, straits and channels, areas of high rugosity, areas of terrestrial nutrient input); and b) hydrographic features, persistent or ephemeral (coastal upwellings, fronts and frontal systems, currents, eddies and eddy fields, oxygen minimum zone shoaling, thermocline shoaling, retention areas, divergence/convergence zones, oceanic gyres).

6.3. EUNIS pelagic water column habitat classification

Habitat classification forms an integral part of the *European Nature Information System* (EUNIS), developed and managed by the European Topic Centre for Nature Protection and Biodiversity (ETC/NPB in Paris) for the European Environment Agency (EEA) and the European Environmental Information Observation Network (EIONET). The EUNIS habitat system consists of a database together with explanatory documentation. EUNIS habitats are arranged in a hierarchy, starting at level 1. They provide a comprehensive typology for the habitats of Europe, terrestrial and marine, and its adjoining seas. Davies et al. (2004) provided full documentation of EUNIS habitats to level 4 for marine habitats.
The box below lists 10 different habitat types pertaining to the pelagic water column, included in the EUNIS classification.

A: Marine habitats [2]

A7: Pelagic water column

A7.1 Neuston (The interface between air and sea water, inhabited by communities of minute or microscopic organisms)

A7.2 Completely mixed water column with reduced salinity (A water column which is completely and actively mixed, and influenced by freshwater so that the salinity is reduced relative to the adjacent fully marine seawater. This habitat type is usually found in relatively shallow, coastal situations, and is the result of river inflow or ice melt. Note that some discretion should be used in the interpretation of “adjacent”, for example in the Baltic Sea, “adjacent” fully marine seawater is reached only in the Kattegat).

A7.3 Completely mixed water column with full salinity (A water column which is completely and actively mixed, not influenced by freshwater, so that the salinity is the same as that in adjacent seawater. This habitat type is usually found in relatively shallow, coastal situations, without river inflow or ice melt).

A7.4 Partially mixed water column with reduced salinity and medium or long residence time (A water column which is unmixed or only partially mixed because the depth of the water body is greater than the depth of mixing. Salinity is reduced relative to the adjacent fully marine seawater. This habitat type is usually found in deeper coastal water situations and is the result of river inflow or ice melt. Note that some discretion should be used in the interpretation of “adjacent”, for example in the Baltic Sea, “adjacent” fully marine seawater is reached only in the Kattegat. Medium residence time is defined as changing over time periods greater than daily and up to about 14 days (based on the time required for the phytoplankton population to double) and long residence time lasting longer than 14 days).

A7.5 Unstratified water column with reduced salinity (A water column which is unmixed or only partially mixed because the depth of the water body is greater than the depth of mixing, and with short residence time, defined as changing diurnally. Salinity is reduced relative to the adjacent fully marine seawater. This habitat type is usually found in deeper coastal water situations and is the result of river inflow or ice melt. Note that some discretion should be used in the interpretation of “adjacent”, for example in the Baltic Sea, “adjacent” fully marine seawater is reached only in the Kattegat. Unstratified water columns have very weak or no horizontal or vertical gradients).

A7.6 Vertically stratified water column with reduced salinity (A water column which is unmixed or only partially mixed because the depth of the water body is greater than the depth of mixing, and with short residence time, defined as changing diurnally. Salinity is reduced relative to the adjacent fully marine seawater. This habitat type is usually found in deeper coastal water situations and is the result of river inflow or ice melt. Note that some discretion should be used in the interpretation of “adjacent”, for example in the Baltic Sea, “adjacent” fully marine seawater is reached only in the Kattegat. This habitat type shows pronounced vertical stratification (e.g. caused by seasonal temperature changes, river discharge influence or ice-melt). The subtypes are separated at level 4 by the cause and degree of persistence of the gradient – e.g. seasonal temperature gradients or persistent salinity gradients).

A7.7 Fronts in reduced salinity water column (A water column which is unmixed or only partially mixed because the depth of the water body is greater than the depth of mixing, and with short residence time, defined as changing diurnally. Salinity is reduced relative to the adjacent fully marine seawater. This habitat type is usually found in deeper coastal water situations and is the result of river inflow or ice melt. Note that some discretion should be used in the interpretation of “adjacent”, for example in the Baltic Sea, “adjacent” fully marine seawater is reached only in the Kattegat. Horizontal gradients give rise to fronts, which are separated at level 4 by the degree of persistence of the stratification).

A7.8 Unstratified water column with full salinity (A water column which is unmixed or only partially mixed because the depth of the water body is greater than the depth of mixing. Salinity is the same as that in adjacent seawater. Unstratified water columns have very weak or no horizontal or vertical gradients).

A7.9 Vertically stratified water column with full salinity (A water column which is unmixed or only partially mixed because the depth of the water body is greater than the depth of mixing. Salinity is the same as that in adjacent seawater. This habitat type shows pronounced vertical stratification (e.g. caused by atmospheric temperature). The subtypes are separated at level 4 by the cause and degree of persistence of the gradient – e.g. seasonal temperature gradients or persistent salinity gradients).

A7.A Fronts in full salinity water column (A water column which is unmixed or only partially mixed because the depth of the water body is greater than the depth of mixing. Salinity is the same as that in adjacent seawater. Horizontal gradients give rise to fronts, which are separated at level 4 by the degree of persistence of the stratification – ephemeral such as eddies, gyres and upwellings; seasonal upwellings; or persistent water mass interfaces).

[2] http://eunis.eea.europa.eu/habitats-code-browser.jsp?expand=A,A7#level_A7

Davies et al. (2004) also provide a set of criteria diagrams with additional detailed explanatory notes accompanying each grey “decision box” in the diagram, to aid in the identification of the different habitats to level 3. The diagram for Level A7 (pelagic water column) is presented in Fig. 2, followed by the accompanying notes.

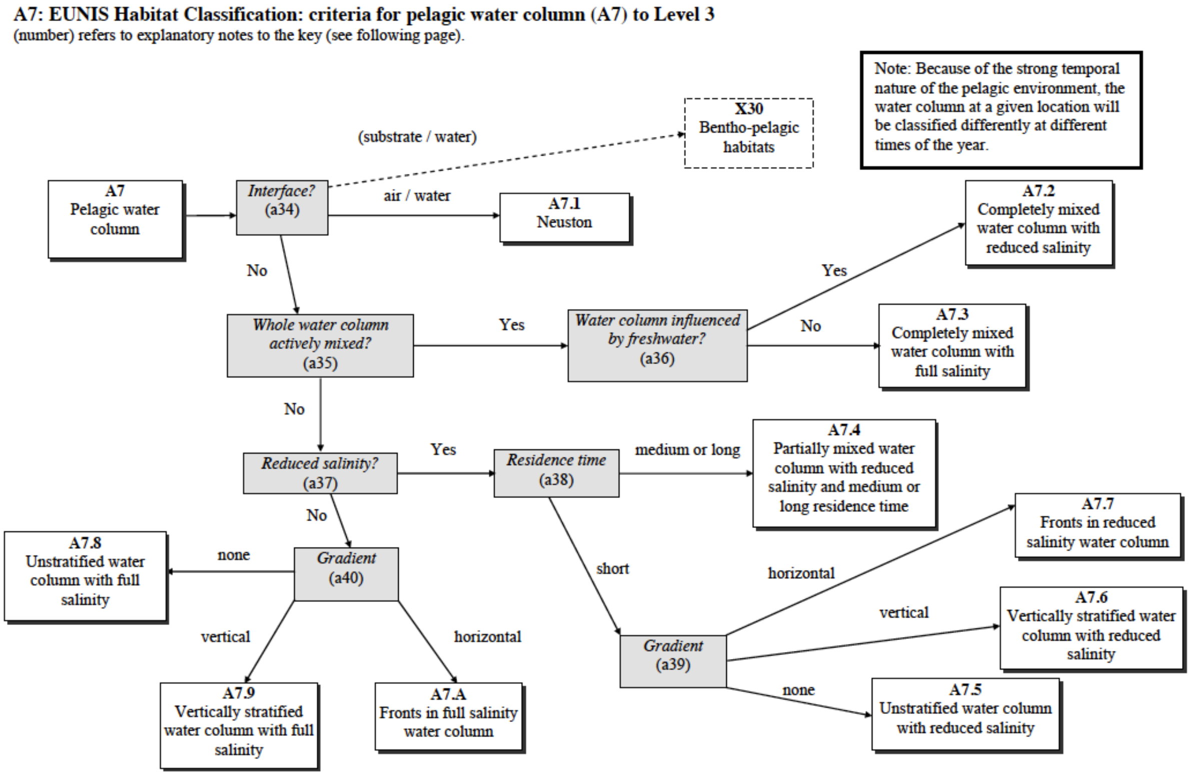


Fig. 2 – EUNIS criteria for pelagic water column habitats (from Davies et al. 2004).

a34. Is the habitat developed at the interface between *air / water;* or in the main water column (path = *No*)? Note that where the habitat is developed at the interface between the substrate and water it is best described as complex X30 - a combination of units from A1 to A6 with units from A7.

a35. Is the water column completely and actively mixed, usually due to its relatively shallow nature, (Path = *Yes*), or is it unmixed or only partially mixed because the depth of the water body is greater than the depth of mixing (Path = *No*)?

a36. Is the water column influenced by freshwater i.e. is the salinity reduced relative to the adjacent fully marine seawater (Path = *Yes*)? These units are usually found in relatively shallow, coastal situations, and are the result of river inflow or ice melt. Note that some discretion should be used in the interpretation of ‘adjacent’, for example in the Baltic Sea, ‘adjacent’ fully marine seawater is reached only in the Kattegat.

a37. Water columns which are not fully mixed and which have reduced salinity relative to the adjacent fully marine seawater are separated (Path = *Yes*). These units are usually found in deeper coastal water situations and are the result of river inflow or ice melt. Note that some discretion should be used in the interpretation of ‘adjacent’, for example in the Baltic Sea, ‘adjacent’ fully marine seawater is reached only in the Kattegat.

a38. Partially mixed reduced salinity waters with a *short* residence time are separated from those with *medium or long* residence times. Short residence time is defined as changing diurnally, medium residence time is greater than daily and up to about 14 days (based on the time required for the phytoplankton population to double) and long residence time lasting longer than 14 days.

a39. Reduced salinity habitats with short residence time are distinguished by the type and degree of gradient: those with pronounced *vertical* stratification (e.g. caused by seasonal temperature changes, river discharge influence or ice-melt); *horizontal* gradients giving rise to fronts; and those with very weak gradients or *none*. Note that units with vertical stratification are separated at level 4 by the cause and degree of persistence of the gradient – e.g. seasonal temperature gradients or persistent salinity gradients etc. Units with horizontal stratification are separated at level 4 by the degree of persistence of the stratification.

a40. Full salinity habitats characterised by the degree and direction of gradient are distinguished: those with pronounced *vertical* stratification (e.g. caused by atmospheric temperature); *horizontal* gradients giving rise to fronts; and those with very weak gradients or *none*. Note that units with horizontal stratification are separated at level 4 by the degree of persistence of the stratification – ephemeral such as eddies, gyres and upwellings; seasonal upwellings; or persistent water mass interfaces.

6.4. Guidance for reporting under the Marine Strategy Framework Directive.

The guidelines for reporting under the *Marine Strategy Framework Directive* (European Commission 2012) contain, in Annex 1, reference and term lists dealing with habitat features. These include, under the category "water column habitats", the following divisions:

- Reduced salinity water
- Variable salinity (estuarine) water
- Marine water: coastal[3]
- Marine water: shelf
- Marine water: oceanic

These represent a somewhat simplified version of the EUNIS classification, based in part on salinity levels, and in part on considerations of depth and distance from land. European Union Member States are expected to report on their MSFD obligations according to such classification, which would make it desirable to consider following a similar approach also within a UNEP-MAP framework.

[3] For coastal waters there is a normative definition in the EU Water Framework Directive: "'Coastal water' means surface water on the landward side of a line, every point of which is at a distance of one nautical mile on the seaward side from the nearest point of the baseline from which the breadth of territorial waters is measured, extending where appropriate up to the outer limit of transitional waters". In other words, coastal waters sensu WFD (and presumably also affecting reporting for the MSFD) are the 1st nautical mile of neritic waters. Consequently, for the purposes of this document the two relevant categories of marine waters are "**shelf**" (= "neritic"), and "**oceanic**".

6.5. Classification based on primary productivity in the euphotic layer

Of particular relevance to the effort of establishing a reference list of pelagic habitat types in the Mediterranean is a simplified pelagic habitat classification, tailored to the region, based on the level of primary productivity in the euphotic layer (i.e., to a depth of ~200 m). This classification was developed in large part to aid in the derivation of potential feeding and breeding habitat of bluefin tuna (Druon et al. 2011) and fin whales (Druon et al. 2012) in the Mediterranean, through habitat modelling.
The classification is based on approximate chlorophyll (CHL) concentration categories, and only apply to the upper 200 m of the water column (J.-N. Druon, pers. comm.):

high surface CHL (>3 mg/m^3)	river plumes (Druon et al. 2005, Djavidnia et al. 2005)
medium surface CHL (0.5-3 mg/m^3)	upwelling, re-suspension in shallow waters and outskirt of river plume (marine waters) (Druon et al. 2005)
low surface CHL (~0.1-0.5 mg/m^3)	chlorophyll-a fronts (whatever type of horizontal gradient of CHL, thus including e.g. gyres) (Druon et al. 2011, 2012)
very low surface CHL (<0.1 mg/m^3) with subsurface CHL maximum	euphotic depth > mixed layer depth
very low surface CHL (<0.1 mg/m^3) without subsurface CHL maximum	euphotic depth < mixed layer depth

7. Towards a reference list of Mediterranean pelagic habitats

Compiling a reference list of benthic habitats, as was done for the Mediterranean (UNEP-MAP-RAC/SPA 2006), has clear and immediate conservation value because such list is needed in the preparation of national inventories of natural sites of conservation interest. Benthic habitats can be considered as fixed (although boundaries of some such habitats can slowly move in response to environmental change and human-induced disturbance), can be taken as proxies for biodiversity hotspots which are normally associated with such habitats, and that might warrant protective efforts. Accordingly, disposing of a reference list of benthic habitats makes mapping possible, and, in turn, facilitates conservation action.
The situation is radically different when dealing with pelagic habitats, which are subject to wide and rapid fluctuations both at the spatial and temporal scales due to the inherent fluidity and continuous movement of the water masses (see Introduction). Furthermore, unlike the benthos, the pelagic realm is tri-dimensional, difficult to inspect, mostly located far from land, and although consisting of a wide variety of combinations of physical and chemical characteristics which creates different habitats that marine species readily react to, such habitats cannot be detected by humans without the assistance of sophisticated instrumentation.

As a consequence of the radical differences between the two realms, whereas in the benthic realm habitat is often used as a proxy for biodiversity, in the pelagic realm the opposite normally happens, i.e., the distribution of pelagic biodiversity – which in many cases is easier to detect than pelagic habitats, e.g., through field surveys, echosounder detection or fishery reports - can be taken as an indication of the distribution of pelagic habitats. This consideration, however, should not decrease the impetus for classifying pelagic habitats; in many cases, for example, it is possible to identify predictors of pelagic biodiversity hotspots through the remote measurement of selected abiotic metrics such as ocean colour and SST.

For the above reasons, a first attempt at classifying pelagic habitats in the Mediterranean, which is also relevant for the species groups addressed by the EcAp process, could involve placing an emphasis on the distribution of primary productivity, based on the scheme recommended by J.-N. Druon (Joint Research Centre, Ispra, pers. comm.), in combination with the guidance for reporting under the MSFD (European Commission 2012). The latter represents a simplification of EUNIS, a classification which is more relevant and applicable to Northern European seas (shallower and less saline) than in the Mediterranean.

The relevance of a draft classification based on productivity for the species groups addressed by the EcAp process (marine mammals, birds and reptiles) is conditional to the assumption that the distribution of prey is the main determinant of habitat choice by such species. This, however, is an assumption that needs further verification and is unlikely to apply to all species and all times. Although Yen et al. (2004), considering the distribution in relation to bathymetry of the most abundant pelagic marine birds and mammals in the north-eastern Pacific Ocean, demonstrated that these species are largely associated with bathymetric features and shallow-water topographies, thus highlighting the importance of bathymetric associations of upper-trophic level predators to delineate sites of elevated trophic transfer.

Many of the bathymetric and oceanographic features responsible for higher concentrations of marine biodiversity in the water column, originally discussed by Hyrenbach et al. (2000) and listed by Dunn et al. (2011) as features that could meet the EBSA criteria, ultimately owe their relevance, at least in part, to their contribution to the enhancement of primary productivity in the euphotic layer. These include static bathymetric features (such as continental shelf breaks, areas of steep slope, straits and channels) and hydrographic features (such as coastal upwellings, fronts and frontal systems, currents, eddies and eddy fields, divergence/convergence zones). Biological productivity can be enhanced at the sea surface either through direct increases in productivity (e.g., in upwelling regions), or through spatial or temporal aggregation of productivity, such as in fronts and convergence zones (Dunn et al. 2011). A number of mechanisms have been identified that result in high biological productivity, including areas of wind-driven or topographically-induced upwelling. Other mechanisms, such as advection and mixing, may result in increased nutrient availability. Thermocline and oxycline shoaling can also result in elevated productivity by concentrating productivity vertically. Aggregating features such as eddies and fronts retain and concentrate productivity both vertically and horizontally and can persist from days to months. Topographic features also increase biological productivity, either by physical forcing (interruptions of flow, upwelling, etc.) or by congregating productivity. These features include canyons, shelf breaks, islands and seamounts.

Dunn et al. (2011) identified three conditions to be used in determining the importance of areas for productivity:
a) higher biomass or productivity than surrounding areas;
b) at least one level of trophic transfer (for biologically productive areas there must be some sort of biological forcing that is transferred between trophic levels which may not be the case at, for example, calving or spawning grounds in which no foraging occurs); and
c) be persistent or recurrent in space and time.

Considering all of the above, an initial draft reference list of pelagic habitat types in the Mediterranean Sea could consist of the following:

A. Epipelagic layer (0 – 200 m):

A.1.	Reduced salinity water	coastal lagoons
A.2.	Variable salinity water - high surface CHL (>3 mg/m^3)	estuaries, river plumes
A.3.	Marine water: neritic - medium surface CHL (0.5-3 mg/m^3)	upwellings, re-suspension in shallow waters and outskirts of river plumes
A.4.	Marine water: oceanic - medium surface CHL (0.5-3 mg/m^3)	upwellings
A.5.	Marine water: oceanic - low surface CHL (~0.1-0.5 mg/m^3)	chlorophyll-a fronts (whatever type of horizontal gradient of CHL, thus including e.g. gyres)
A.6a.	Marine water: oceanic - very low surface CHL (<0.1 mg/m^3) with subsurface CHL maximum	euphotic depth > mixed layer depth
A.6b.	Marine water: oceanic - very low surface CHL (<0.1 mg/m^3) without subsurface CHL maximum	euphotic depth < mixed layer depth

With the exception of A.6, all the habitat types listed above can be detected by satellite, which makes the proposed classification practically amenable to continuous monitoring over the whole Mediterranean region.

Concerning A.6, it must be noted that maxima of subsurface CHL are not detected by ocean colour telemetry, and will have to be measured *in situ*. This is of course an inevitable complication, which is however known to occur in Mediterranean waters. For instance, McGehee et al. (2004) reported the occurrence of subsurface CHL maxima in the Ligurian Sea in summer 1999, which they attributed to the presence of a dome of dense water in the centre of the basin, consistent with both a geostrophically-driven counterclockwise current (the Ligurian Current) and central basin upwelling (Fig. 3).

This condition had relevant consequences on the distribution of fin whales in their Ligurian Sea feeding habitat, but was completely missed by satellite-derived CHL level measurements at the surface.[4]

[4] See: NASA Ocean Color Radiometry Online Visualization and Analysis, August 1999, at: http://tiny.cc/4cloxw

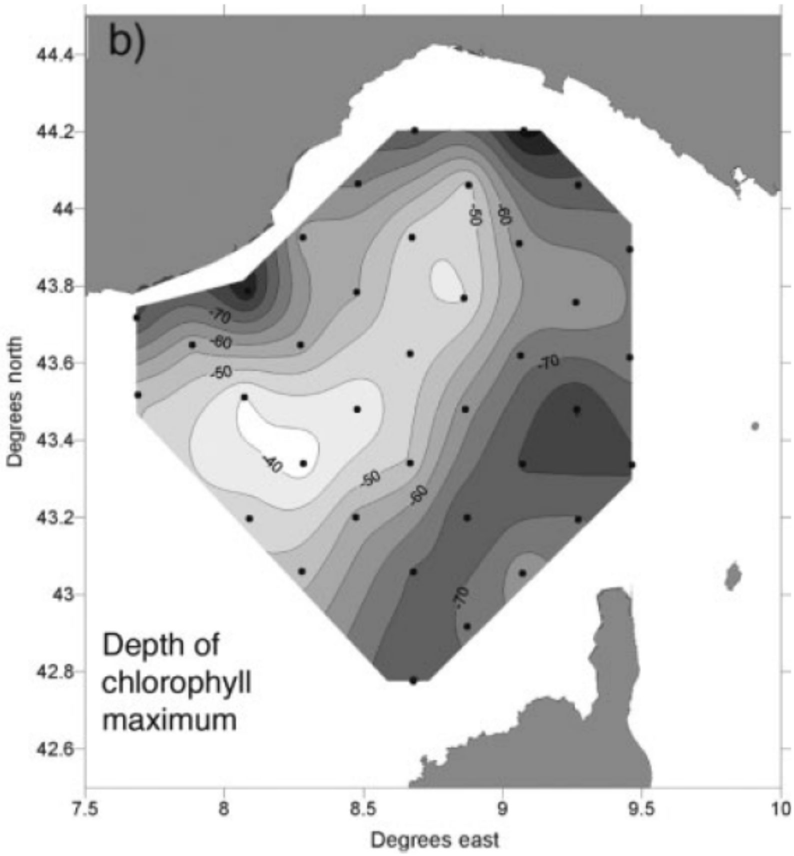


Fig. 3 – Subsurface CHL maximum which occurred in the Ligurian Sea in summer 1999 (from McGehee et al. 2004).

Proposing a reference list of pelagic habitats in the mesopelagic, bathypelagic and abyssopelagic layers (200 – 6,000 m) is far more challenging for the reasons discussed in the previous pages (e.g., in the Introduction), particularly considering the complex structuring and dynamics of the different Mediterranean water masses. Fortunately these layers are much less relevant for the species selected for the EcAp process: birds (with the exception of penguins) are not known to venture below epipelagic depths, and also loggerhead and green turtles normally remain in the upper 10s of m in the water column. Many cetaceans (see Section 5) dive to mesopelagic waters, and some even beyond, however these dives are performed in search of food, and the animals are forced to return to the surface in a range of 10s-100s of minutes after the beginning of their dives.

Clearly, identifying and classifying pelagic habitat types beyond the epipelagic layer is a very complex task requiring a good understanding of the interplay between abiotic (i.e., depth, temperature, salinity and currents) and biotic factors, and of the time and space scales involved in such interplay.

As a consequence, it is recommended that an effort of compiling a reference list of Mediterranean pelagic habitat types be achieved through in-depth multidisciplinary expert consultations.

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Appendix

Mammals, birds and reptiles listed in Annex II to the SPA/BD Protocol

(Species **in bold** are represented in the Mediterranean marine waters
by regularly present populations)

Mammals	*Balaenoptera acutorostrata*	minke whale
	Balaenoptera borealis	sei whale
	Balaenoptera physalus	**fin whale**
	Delphinus delphis	**short-beaked common dolphin**
	Eubalaena glacialis	North Atlantic right whale
	Globicephala melas	**Long-finned pilot whale**
	Grampus griseus	**Risso's dolphin**
	Kogia sima	dwarf sperm whale
	Megaptera novaeangliae	humpback whale
	Mesoplodon densirostris	Blainville's beaked whale
	Monachus monachus	**Mediterranean monk seal**
	Orcinus orca	**killer whale**
	Phocoena phocoena	**harbour porpoise**
	Physeter macrocephalus	**sperm whale**
	Pseudorca crassidens	false killer whale
	Stenella coeruleoalba	**striped dolphin**
	Steno bredanensis	**rough-toothed dolphin**
	Tursiops truncatus	**common bottlenose dolphin**
	Ziphius cavirostris	**Cuvier's beaked whale**
Birds	***Pandion haliaetus***	**osprey**
	Calonectris diomedea	**Cory's shearwater**
	Falco eleonorae	**Eleonora's falcon**
	Hydrobates pelagicus	**European storm petrel**
	Larus audouinii	**Audouin's gull**
	Numenius tenuirostris	**slender-billed curlew**
	Phalacrocorax aristotelis	**common shag**
	Phalacrocorax pygmaeus	**pygmy cormorant**
	Pelecanus onocrotalus	**great white pelican**
	Pelecanus crispus	**Dalmatian pelican**
	Phoenicopterus ruber	**flamingo**
	Puffinus yelkouan	**yelkouan shearwater**
	Sterna albifrons	**little tern**
	Sterna bengalensis	**lesser crested tern**
	Sterna sandvicensis	**Sandwich tern**
Reptiles	***Caretta caretta***	**loggerhead turtle**
	Chelonia mydas	**green turtle**
	Dermochelys coriacea	leatherback turtle
	Eretmochelys imbricata	hawksbill turtle
	Lepidochelys kempii	Kemp's Ridley turtle
	Trionyx triunguis	African softshell turtle