Manual of marine and coastal datasets of biodiversity importance

2015 edition

An introduction to key marine and coastal biodiversity datasets

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Team (UNEP-WCMC)

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Edition

This Manual was first published by Martin *et al*. in 2014. The 2015 edition includes updated annexes (53 new datasets and 24 additional metadata sheets), with minor edits throughout the main text.

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Contents

Executive summary

English. Knowledge of marine and coastal datasets tends to be fragmented and/or difficult to access for the non-expert or *ad hoc* data user. To address this lack of information, this document provides an overview of global marine and coastal datasets of biodiversity importance, and also includes some datasets of regional interest. This non-exhaustive review has resulted in the identification of 128 datasets, databases, and data portals. Detailed standardised metadata are presented for 69 of these reviewed datasets. The various challenges, gaps and limitations that can be presented by coastal and marine data are also discussed. A set of four annexes provides a wealth of information, including background factsheets on topic areas (Annex 1), a preliminary inventory of 128 global and regional datasets (Annex 2) and dataset-specific metadata on 69 of these (Annex 3). Annex 4 contains a sample of 10 marine mammal spatial distribution maps, as modelled using the AquaMaps approach.

Français. La connaissance des données marines et côtières est généralement fragmentée et/ou difficile d'accès pour le non-expert ou l'utilisateur ad hoc. Pour remédier à ce manque d'information, ce document donne un aperçu des données marines et côtières d'importance pour la biodiversité, à l'échelle mondiale, et inclut également des données d'intérêt régional. Cet inventaire non exhaustif a permis d'identifier 128 ensembles et/ou portails de données. Des métadonnées détaillées et standardisées sont présentées pour 69 d'entre eux. Les défis, lacunes et limites qui peuvent être présentés par les données marines et côtières sont également discutés. Quatre annexes fournissent de nombreux renseignements: des fiches thématiques (Annexe 1), un inventaire préliminaire de 128 ensembles et/ou portails de données aux échelles mondiales et régionales (Annexe 2), et des métadonnées pour 69 d'entre eux (Annexe 3). L'annexe 4 présente un échantillon de cartes de distribution pour 10 mammifères marins, basées sur l'approche de modélisation AquaMaps.

Español. El conocimiento acerca de los conjuntos de datos marinos y costeros tiende a ser incompleto y/o no siempre está al alcance de las personas no expertas o los usuarios ad hoc. Para remediar estas carencias referentes a la información, este documento pretende ofrecer un sumario que agrupe todos los datos marinos y costeros de importancia para la biodiversidad a nivel mundial, e incluye además conjuntos de datos de interés regional. Este inventario no exhaustivo ha permitido identificar 128 conjuntos y/o portales de datos. Para 69 de estos 128 conjuntos se presentan metadatos detallados y estandarizados. Los desafíos, lagunas y limitaciones que podrían surgir a partir de estos datos son igualmente discutidos. Cuatro anexos proporcionan numerosas reseñas: fichas temáticas (Anexo 1), un inventario preliminar con 128 conjuntos de datos a escala mundial y regional (Anexo 2), y metadatos para al menos 45 de ellos (Anexo 3). El Anexo 4 contiene una muestra de mapas de distribución para 10 mamíferos marinos, todos ellos basados en una modelización obtenida a través de AquaMaps.

Русский. Знание о морских и прибрежных массивах данных, как правило, имеет фрагментарный характер и / или к нему трудно получить доступ неэкспертным или специальным пользователям данных. Для решения этой отсутствия информации, В настоящем документе содержится обзор мировых морских и прибрежных массивов данных, имеющих важное значение для биоразнообразия, а также определяются несколько массивов данных, представляющих интерес для регионов. Это не исчерпывающий обзор, который привело к идентификации 128 массивов данных, баз данных и информационных порталов. Подробные стандартизированные метаданные представлены для 69 из этих рассмотренных массивов данных. Обсуждаются также различные проблемы, пробелы и ограничения, которые могут быть представлены прибрежными и морскими данных. Ряд четырех приложений содержат богатство информации, в том числе и вспомогательные справочные материалы по тематическим областям (приложение 1), предварительная перечень 128 глобальных и региональных массивов данных (Приложение 2) и специфичные метаданные для 69 из этих массив данных (Приложение 3) . В приложении 4 содержится образец 10 карт пространственного распределения морских млекопитающих, смоделированных с помощью подхода «AquaMaps».

中文. 关于海洋与海岸数据的知识通常是碎片化的，并且往往对非专业人员和一次性数据用户而言，难以获取。为了解决这方面信息缺乏的情况，本报告对全球重要的海洋和海岸生物多样性数据提供了一个概括，其中包括了相关的区域尺度的数据。这份非详尽的概括涵盖了128个数据集、数据库和数据门户，其中的69个包含了详细的、标准化的元数据；并讨论了关于海洋和海岸数据的挑战、数据缺口以及局限性。位于报告最后的四张附录提供了丰富的信息，他们分别是背景资料简报（附录1），128个全球和地区尺度数据的初步清单（附录2），69个数据的元数据（附录3）和10类海洋哺乳动物的空间分布地图样本（附录4，使用AquaMaps方法）。

.العربية إليها الوصول يصعب أو / ومجزأة تكون أن إلى تميل والساحلية البحرية البيانات قواعد معرفة لمحة الوثيقة هذه وتقدم المعلومات، في النقص هذا لمعالجة .المستخدمة البيانات مخصصة أو الخبراء لغير بعض أيضا وتشمل والعالمية، البحري البيولوجي التنوع أهمية الساحلية البيانات قواعد عن عامة قواعد 128 تحديد في حصري غير الاستعراض هذا أدى وقد .الإقليمية الأهمية ذات البيانات مجموعات هذه من 69ل مفصل موحد الوصف البيانات عرض يتم .البيانات وبوابات البيانات، وقواعد البيانات يقدمها أن يمكن التي والقيود الثغرات التحديات مختلف أيضا وتناقش .استعراضها تم التي المجموعات ذلك في بما المعلومات، من ثروة يوفر مرفقات أربعة من مجموعة وهناك .والبحرية الساحلية البيانات العالمية البيانات قواعد 128 من أولية وقائمة ،(1 الملحق) الموضوع مناطق عن أساسية حقائق وثيقة 4 المرفق ويتضمن .(3 الملحق) هؤلاء من 69 عن محددة بيانات الوصفية والبيانات (2 الملحق) والإقليمية AquaMaps. نهج باستخدام غرار وعلى المكاني، التوزيع خرائط البحرية الثديات 10 من عينة

1. Introduction

Knowledge of marine and coastal datasets tends to be fragmented and often difficult to access for the non-expert or *ad hoc* data user. Data users may find it difficult to assess the suitability of a particular dataset for their specific needs, and to access the information necessary for optimal use of these data. These issues can be compounded by a lack of information on the biodiversity features for which there are datasets available. To address this lack of information, this document provides an overview of global marine and coastal datasets of biodiversity importance, including some datasets of regional interest.

In this document, *datasets of biodiversity importance* are defined as those datasets that can be used to identify geographic areas which contain significant biodiversity, in the broadest sense of the term. We define as *marine* a dataset covering a section of the sea, without any terrestrial component (e.g. coral, seagrass bed), whilst a *coastal dataset* would have both a marine and a terrestrial component (e.g. mangrove, saltmarsh).

In addition to the information provided on existing datasets, the various challenges, gaps and limitation which can be presented by coastal and marine data are also discussed (section 4), including spatial and temporal gaps and bias, data types (e.g. point, polygon), modelled versus observed data, and spatial and temporal scales. The ways in which the scientific community aims to address these availability and quality issues are also highlighted. Such issues also exist in the terrestrial realm, but they tend to be significantly more acute in the marine realm: data users are confronted with significant and specific difficulties in the identification and use of coastal and marine datasets.

The document is structured as follows:

- *section 2* gives some background to the work and discusses the scope of the review;
- *section 3* provides information on the different datasets reviewed and highlights how these have been grouped into 11 categories;
- *section 4* discusses the issues around data and highlights the gaps which can occur, along with some additional information on data use; and
- a set of four annexes provides a wealth of information including links to background factsheets on topic areas (*Annex 1*), a preliminary inventory of global datasets (*Annex 2*), and dataset-specific metadata on a subset of these datasets (*Annex 3*). *Annex 4* contains a sample of marine mammal spatial distribution maps, as modelled using the AquaMaps approach.

It is hoped that these documents will improve understanding of the different datasets that have been produced by various organisations around the world.

2. Aim and scope

The starting point for this work was an identified need to better document and explain the various marine and coastal datasets currently curated and/or distributed by the United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC), including what these datasets show, why they were created, how they can be used, their limitations, and access details (such as the data owner details, use restrictions, web map service links[3]). To date, more than 30 marine and coastal datasets can be viewed and/or downloaded from UNEP-WCMC's *Ocean Data Viewer*[4] (ODV). This documentation work resulted in the development of standardised 'metadata'[5] sheets for each of these datasets, as well as for other datasets internally curated by UNEP-WCMC that are not available through this online data portal.

The scope of the work included an initial review of marine and coastal datasets of biodiversity importance created and curated by UNEP-WCMC and other organisations or scientific initiatives. This non-exhaustive review resulted in the identification of a total of 128[6] datasets and/or databases and data portals. Datasets were grouped into 11 broad categories listed in Table 1. To date, UNEP-WCMC has produced detailed standardized metadata[7] for 69 of these reviewed datasets. These metadata were written in the same standardized format as the information produced for datasets curated by UNEP-WCMC to provide a comparable source of information for the variety of datasets that have been created for the marine environment. Standardised metadata were created to collate, as far as possible, all relevant information on the individual datasets into one location for ease of access and comparison.

In addition to the dataset-specific metadata, complementary 'background factsheets', often relevant to several datasets, were developed to provide general information on biodiversity features (e.g. ecology, creation methodology, etc.), and explanations of its biodiversity importance including, where relevant, policy and governance aspects. Hyperlinks to background factsheets that are available to date are provided in Table 1.

[3] These can be used in web mapping applications such as ArcGIS.com, SeaSketch, etc.
[4] http://data.unep-wcmc.org. Note that protected area data are downloadable from Protected Planet (http://www.protectedplanet.net/), not from the ODV. For commercial use of these datasets, please contact business-support@unep-wcmc.org.
[5] Metadata are "data about data".
[6] See Annex 2 for a summary table listing all the datasets reviewed.
[7] See Annex 3 for a compilation of metadata sheets available to date. Metadata were written in priority for datasets curated/distributed by UNEP-WCMC, and for datasets likely to be of interest to UNEP-WCMC within the framework of its projects.

Table 1. Eleven broad categories used to classify the 128 datasets that have been inventoried. Associated background factsheets are available on the *Biodiversity A-Z*[8]. SDM: Species Distribution Modelling (see section 4).

Category	Factsheet name	Factsheet URL
Biogenic habitat	Warm-water coral reef	http://wcmc.io/warm_coral_reef
	Cold-water coral	http://wcmc.io/cold-coral
	Mangrove	http://wcmc.io/mangroves
	Seagrass	http://wcmc.io/seagrass
	Saltmarsh	http://wcmc.io/saltmarsh
Species habitat	Marine turtle (nesting site)	http://wcmc.io/turtle-nesting-site
Species distribution		
Biodiversity metric		
Area of biodiversity importance	Marine Protected Area	http://wcmc.io/MPA
	Key Biodiversity Areas	http://wcmc.io/KBA
	Ecologically or Biologically Sensitive Area	http://wcmc.io/EBSA
	Vulnerable Marine Ecosystem	http://wcmc.io/VME
	Particularly Sensitive Sea Area	http://wcmc.io/PSSA
	UNEP Regional Seas Programme	http://wcmc.io/regional_seas
Biogeographic classification	Global 200 Ecoregions	http://wcmc.io/ecoregions
	Seamount	http://wcmc.io/seamounts
	Hydrothermal vent	http://wcmc.io/vents
	Cold seep	http://wcmc.io/seeps
Environment descriptor	Environment descriptor	http://wcmc.io/environment-descriptors
Ecosystem services and natural capital		
Ecological status and impact		
Databases and data portal		
Administration		

This document is by no means an exhaustive inventory of all existing datasets of biodiversity importance. Rather, it should be considered a *living* document that will be continuously updated as more datasets are created and feedback is received. In this regard, we welcome comments from data curators, owners, users and experts so that this document can be maintained as accurate, updated and useful as possible. Further factsheets are also planned and will be included in future updates of this document. It is hoped that this document will facilitate access to, understanding of, and effective use of marine and coastal datasets of biodiversity importance.

[8] http://www.biodiversitya-z.org

3. Key marine and coastal biodiversity datasets

Thirteen broad categories (see Table 1 in Section 2) were used to classify the 128 marine and coastal datasets we identified. In this section, the identified datasets are listed by category, the availability of metadata in Annex 3 is indicated (✓), and the hyperlink to the associated background factsheet (where available) is noted. Datasets that are currently **downloadable** from UNEP-WCMC's *Ocean Data Viewer* are indicated using coloured shading.

Biogenic habitat

'Biogenic' habitats are those habitats created by plants or animals, and that grow in such manner that they provide a unique environment and physical structure for other organisms to live (Tyrrell 2005). Examples of marine and coastal biogenic habitats include (warm- and cold-water) corals, mangroves, saltmarshes, seagrass meadows and kelp beds.

Table 2. Global (and regional) datasets in the 'biogenic habitat' category. Coloured shading indicates that the datasets are directly downloadable from the *Ocean Data Viewer*.

Resource title	ID[9]	Metadata	Factsheet URL
Global Distribution of Coral Reefs (2010)	WCMC-008	✓	http://wcmc.io/warm_coral_reef
Global Distribution of Coral Reefs - 1 Km Data (2003)	WCMC-009	✓	http://wcmc.io/warm_coral_reef
Global Distribution of Cold-water Corals (2005)	WCMC-001	✓	http://wcmc.io/cold-coral
Global Distributions of Habitat Suitability for Framework-Forming Cold-Water Corals (2011)	Bangor-001	✓	http://wcmc.io/cold-coral
Global Distribution of Habitat Suitability for Stony Corals on Seamounts (2009)	WCMC-024		http://wcmc.io/cold-coral
Global Distributions of Habitat Suitability for Cold-Water Octocorals (2012)	ZSL-001	✓	http://wcmc.io/cold-coral
Modelled Mediterranean Coralligenous and Mäerl Distributions (2014)	Mediseh-001	✓	
Global Distribution of Mangroves USGS (2011)	WCMC-010	✓	http://wcmc.io/mangroves
Mangrove Tree Height in Africa (2013)	NASA-001		http://wcmc.io/mangroves
Global Spatiotemporal Database of Mangrove Forest Cover	UniSal-001		http://wcmc.io/mangroves
World Atlas of Mangroves (2010)	WCMC-011	✓	http://wcmc.io/mangroves
Global Distribution of Modelled Mangrove Biomass (2014)	TNC-001	✓	http://wcmc.io/mangroves
World Mangrove Atlas (1997)	WCMC-012	✓	http://wcmc.io/mangroves
Global Distribution of Seagrasses (2005)	WCMC-013-014	✓	http://wcmc.io/seagrass
Modelled *Posidonia oceanica* Distribution in the Mediterranean Sea (2013)	Mediseh-002	✓	http://wcmc.io/seagrass
Global Distribution of Saltmarsh (2013)	WCMC-027	✓	http://wcmc.io/saltmarsh

In this review, we identified 16 datasets (Table 2) showing the global or regional distributions of biogenic habitats, of which 13 have detailed metadata. Two warm-water coral reef, two cold-

[9] Internal UNEP-WCMC numbering system as part of our metadata cataloguing.

water coral reef, and four mangrove datasets can be downloaded from the *Ocean Data Viewer*. Please refer to the detailed metadata to access information on the differences between these datasets and to select the most appropriate dataset for a particular use.

Species habitat

The Convention on Biological Diversity (CBD; 1992) defines habitat as the place or type of site where an organism or population naturally occurs. In this document, the term habitat is understood in the sense of 'biotope', which comprises the abiotic[10] characteristics of a site and the associated biological community. In simple terms, a habitat is where an animal or plant species lives (including migratory routes), feeds (e.g. foraging sites) and reproduces (e.g. breeding, spawning, nesting, and nursery sites). The habitat of a species may hence change throughout its life cycle: fish eggs and larvae for instance are found in very different habitats to juvenile and adult fish. Similarly, female marine turtles lay eggs on nesting beaches but spend the rest of their lives (e.g. foraging, migrating) at sea.

In this review, we identified five datasets (Table 3) showing the global distribution of species habitats, of which two have detailed metadata.

Table 3. Global datasets in the 'species habitat' category. Coloured shading indicates that the datasets are directly downloadable from the *Ocean Data Viewer*.

Resource title	ID	Metadata	Factsheet name
Global Distribution of Marine Turtle Nesting Sites (1999)	WCMC-007	✓	http://wcmc.io/turtle-nesting-site
Global Distribution of Marine Turtle Nesting Sites (2011)	SWOT-001		http://wcmc.io/turtle-nesting-site
Global Distributions of Habitat Suitability for Marine Turtle Nesting Sites (2012)	SWOT-002		http://wcmc.io/turtle-nesting-site
Global Distribution of Marine Turtle Feeding Sites (1999)	WCMC-006	✓	
Fish Aggregation Database	SCRFA-001		

[10] i.e. non-living, applied to the physical and chemical aspects of an organism's environment (http://terms.biodiversitya-z.org/terms/5).

Species distribution

The distribution of a species is understood here as the geographical spaces where the species may be found. Species distributions can be expert-derived or predicted by numerical models, the latter often informing on the relative probability of occurrence at given locations.

In this review, we identified 22 datasets (Table 4) showing the global or regional distributions of species, of which 12 have detailed metadata. Ten of these datasets come from the same source (AquaMaps), with methodological information provided in Annex 4.

Table 4. Global (and regional) datasets in the 'species distribution' category. SDM: Species Distribution Modelling (see section 4).

Resource title	ID	Metadata
Data Portal of the Global Biodiversity Information Facility (GBIF)	GBIF-001	
Ocean Biogeographic Information System (OBIS)	OBIS-003	✓
Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations	OBIS-004	
Corrected and Refined Mangrove Species Ranges (2014)	IUCN-002	✓
Spatial Data for the Red List of Threatened Species	IUCN-001	
Global Register of Migratory Species (2004)	GROMS-001	
Global Distribution of Marine Turtles (2010)	SWOT-003	
AquaMaps: Predicted Range Maps for Aquatic Species (2013)	AquaMaps-001	
Global Distribution of Northern Fur Seals (2013)	Kaschner-001	✓
Global Distribution of Hawaiian Monk Seals (2013)	Kaschner-002	✓
Global Distribution of Grey Seals (2013)	Kaschner-003	✓
Global Distribution of Hector's Dolphins (2013)	Kaschner-004	✓
Global Distribution of Northern Bottlenose Whales (2013)	Kaschner-005	✓
Global Distribution of Sperm Whales (2013)	Kaschner-006	✓
Global Distribution of Bowhead Whales (2013)	Kaschner-008	✓
Global Distribution of Sei Whales (2013)	Kaschner-009	✓
Global Distribution of Atlantic Spotted Dolphins (2013)	Kaschner-011	✓
Global Distribution of Melon-Headed Whales (2013)	Kaschner-012	✓
Marine Species Datasets of the World's Oceans (2014)	OBIS-003	
Global Shark Distribution Database (2009)	UniDalh-002	
Marine Animal Tracking (2013)	UniDalh-001	
Movebank	MovBnk-001	
Tagging of Pacific Predators in the Pacific Ocean	TOPP-001	

Biodiversity metric

Biodiversity metrics are designed to numerically measure the value of biodiversity in space and time. They can, for instance, be used to monitor biodiversity changes through time, or to identify areas of high biodiversity value such as sites showing high levels of species richness.

In this review, we identified five datasets (Table 5) showing the global distribution of biodiversity metrics, of which four have detailed metadata.

Table 5. Global datasets in the 'biodiversity metric' category. Coloured shading indicate that the datasets are directly downloadable from the *Ocean Data Viewer*.

Resource title	ID	Metadata
Global Patterns of Marine Biodiversity (2010)	WCMC-019	✓
Global Map of Shannon's Index of Biodiversity (2014)	OBIS-001	✓
Global Map of Hurlbert's Index of Biodiversity (2014)	OBIS-002	✓
Global Seagrass Species Richness (2003)	WCMC-015	✓
Global Marine Turtle Species Richness (2002)	WCMC-003	

Area of biodiversity importance

Areas of biodiversity importance include a range of nationally and internationally protected areas (e.g. World Heritage Sites, the Natura 2000 network), as well as the many approaches used to highlight areas of biodiversity conservation interest (e.g. Key Biodiversity Areas, Ecologically or Biologically Significant Areas, Critical Habitat).

In this review, we identified nine datasets (Table 6) showing the global distribution of areas of biodiversity importance, of which five have detailed metadata.

Table 6. Global (and regional) datasets in the 'Area of biodiversity importance' category.

Resource title	ID	Metadata	Factsheet name
World Database on Protected Areas (2013)	WCMC-016	✓	http://wcmc.io/MPA
Global Distribution of KBAs, IBAs and AZEs (2013)	Birdlife-001	✓	http://wcmc.io/KBA
Ecologically or Biologically Significant Marine Areas	CBD-001		http://wcmc.io/EBSA
Global Distribution of Vulnerable Marine Ecosystems	FAO-002		http://wcmc.io/VME
Global Distribution of Particularly Sensitive Sea Areas (2012)	IMO-001	✓	http://wcmc.io/PSSA
The Global 200 Ecoregions (2002)	WWF-001		http://wcmc.io/ecoregions
Areas of Particular Environmental Interest (2012)	ISA-001	✓	
A Global Map of Critical Habitat (2015) as per IFC PS6	WCMC-029	✓	
Global Diversity Hotspots and Conservation Priorities for Sharks	Uni-Dahl-003		

Biogeographic classification

Biogeographic classifications are used to understand how and where species are distributed, and to mark the boundaries between oceanographic regimes. They help assessing which habitats, communities and species could be subject to disproportionate impact, because of concentration of human activities, rarity, or limited extent of distribution.

In this review, we identified 12 datasets (Table 7) showing global biogeographic classifications (partial or complete), of which eight have detailed metadata.

Table 7. Global datasets in the 'biogeographic classification' category. Coloured shading indicate that the datasets are directly downloadable from the *Ocean Data Viewer*.

Resource title	ID	Metadata	Factsheet name
Global Estuary Database (2003)	UBC-003	✓	
Marine Ecoregions and Pelagic Provinces of the World (2007; 2012)	WCMC-036	✓	
A Proposed Biogeography of the Deep Oceans (2013)	UniHaw-001		
Coral Ecoregions of the World (2009)	TNC-003	✓	
Large Marine Ecosystems of the World (2002)	NOAA-001	✓	
Longhurst Biogeographical Provinces (2006)	VLIZ-002		
Geomorphology of the oceans (2014)	GridA-001		
Global Distribution of Seamounts and Knolls (2011)	ZSL-002	✓	http://wcmc.io/seamounts
Global Seamount Database (2011)	UniHaw-003		http://wcmc.io/seamounts
Global Distribution of Hydrothermal Vents (2010)	ChEssBase-002	✓	http://wcmc.io/vents
Global Distribution of Hydrothermal Vent Fields	IntRid-001	✓	http://wcmc.io/vents
Global Distribution of Cold Seeps (2010)	ChEssBase-001	✓	http://wcmc.io/seeps

Environment descriptor

Environment descriptors are defined here as variables that can be used to depict the environment. They include physical (e.g. bathymetry, seabed sediment type) and environmental (temperature, salinity) variables, but also biological ones such as productivity. Environment descriptors can be used to monitor environmental changes through space and time, but also as predictors in species distribution models.

In this review, we identified ten datasets (Table 8) showing the global distribution of environment descriptors, of which two have detailed metadata.

Table 8. Global datasets in the 'environment descriptor' category. Coloured shading indicate that the datasets are directly downloadable from the *Ocean Data Viewer*.

Resource title	ID	Metadata	Factsheet name
General Bathymetric Chart of the Oceans (2008)	GEBCO-001		http://wcmc.io/descriptors
Global Sediment Map (marine realm)	SHOM-001		http://wcmc.io/descriptors
Global Crustal Map (2013)	UniCal-002		http://wcmc.io/descriptors
Global Marine Environment Dataset (2014)	GMED-001		http://wcmc.io/descriptors
Bio-ORACLE: a Global Environmental Dataset for Marine Species Distribution Modelling (2012)	Ghent-001		http://wcmc.io/descriptors
Mean Sea Surface Productivity in June and December 2003-2007 (2008)	WCMC-020-021	✓	http://wcmc.io/descriptors

Resource title	ID	Metadata	Factsheet name
Mean Annual Sea Surface Chlorophyll-a Concentration 2009-2013 (2015)	WCMC-034	✓	http://wcmc.io/descriptors
Mean Annual Sea Surface Temperature 2003-2007 (2008)	WCMC-022	✓	http://wcmc.io/descriptors
Mean Annual Sea Surface Temperature 2009-2013 (2015)	WCMC-035	✓	http://wcmc.io/descriptors
AquaMaps Environmental Dataset	AquaMaps-003		http://wcmc.io/descriptors

Ecosystem services and natural capital

Ecosystem services are the benefits people obtain from ecosystems. These include *provisioning services* such as food and water, *regulating services* such as regulation of floods, drought, land degradation, and disease, *supporting services* such as soil formation and nutrient cycling, and *cultural services* such as recreational, spiritual, religious, and other non-material benefits (DEFRA 2007).

In this review, we identified six resources (Table 9) outlining the global distribution of ecosystem services, of which four have detailed metadata.

Table 9. Global datasets in the 'ecosystem services and natural capital' category.

Resource title	Dataset ID	Metadata
Mapping Ocean Wealth	TNC-004	✓
A Global Map of Natural Capital	WCMC-032	✓
Marine Ecosystem Services Partnership	UniDuke-001	✓
A Global Map of Coastal Recreation Values	UniHaif-001	
Sea Around Us	UBC-009	✓
Ocean Past Initiative	HMAP-001	

Ecological status and impact

Ecological status describes the degree to which human uses of the environment have altered the structure and functioning of plant and animal communities. A geographical area can be assigned an ecological status class (e.g. high, good, moderate, poor, or bad) depending on the degree of alteration to the environment in that location. For instance, a *high* ecological status corresponds to areas relatively undisturbed by man, and *good* ecological status to areas where human activities have had only slight impacts on the ecological characteristics of plants and animal communities there. Impact is here understood in the broadest sense of the term, i.e. from disease affecting ecosystems to human impact through diving. Indicators created from measurements of these impacts are used to track changes in ecological status over time.

In this review, we identified 15 datasets (Table 10) showing the global distribution of ecological status and impact, two of which have detailed metadata.

Table 10. Global datasets in the 'Ecological status and impact' category.

Resource title	ID	Metadata
A Global Map of Human Impacts to Marine Ecosystems (2008)	NCEAS-001	
Global Data for the Ocean Health Index (2012)	NCEAS-002	
Spatial and temporal changes in cumulative human impacts on the world's ocean (2015)	NCEAS-003	
Environmental Performance Index (2014)	Yale-002	✓
Living Planet Index (2014)	WWF-002	✓
Reefs at Risk (1998)	WRI-001	
Reefs at Risk Revisited (2011)	WRI-002	
Coral Reef Watch	NOAA-002	
Global Coral Disease Database (2010)	WCMC-004	
Fishing Gear Associated with Global Marine Catches (2008)	UBC-008	
Global and Regional Assessments of the Marine Environment Database	WCMC-038	
Plastic Debris Open Ocean (2014)	UniCadiz-001	
SeagrassNet: Global Seagrass Monitoring Network (2013)	WaDNR-001	✓
Global Restoration Network Database	SER-001	
Undersea Cables	ICPC-001	

Databases and data portals

The databases and data portals listed here offer collections of available data and tools of relevance to marine and coastal biodiversity. These include taxonomic databases that curate classifications and nomenclature for marine and coastal species, and thereby support awareness and management of global marine biodiversity.

In this review, we identified 14 resources (Table 11), of which seven have detailed metadata.

Table 11. Global datasets in the 'databases and data portals' category.

Resource title	Dataset ID	Metadata
Catalogue of Life	CoL-001	✓
World Porifera Database	VLIZ-006	
Mangrove Reference Database and Herbarium	VLIZ-005	
Ocean Data Viewer	WCMC-039	✓
Knowledge Network for Biocomplexity	NCEAS-004	✓
PANGAEA	AWI-001	✓
FishBase	FishBase-001	✓
ReefBase	WorldFish-001	
Map of Life	Yale-001	
Global Distribution of Sea Turtles	SWOT-003	
Environmental Data Explorer	UNEP-003	
UNEP Live	UNEP-004	
Atlas of Global Conservation	TNC-002	✓
Species+	WCMC-037	

Administration

Administrative datasets are essential tools to support spatial analyses of marine and coastal biodiversity, whether it is for impact assessment, or for research and conservation purposes.

In this review, we identified 14 datasets (Table 12) showing the global distribution of administrative data, of which nine have detailed metadata.

Table 12. Global datasets in the 'administration' category.

Resource title	Dataset ID	Metadata
Global Self-consistent, Hierarchical, High-resolution Geography Database (2013)	UniHaw-001	✓
Global Maritime Boundaries Database (2008)	GMBD-001	
Global Administrative Areas	GADM-001	
Global Distribution of Islands IBPoW (2010)	WCMC-005	✓
Global Distribution of Islands OSM (2013)	WCMC-031	✓
Marine Regions Data Portal	VLIZ-003	
Exclusive Economic Zone Boundaries (2012)	VLIZ-001	✓
Regional Seas Boundaries (unofficial)	UNEP-002	✓
Boundaries of the Global International Waters Assessment (2003)	UNEP-001	✓
Global Distribution of Regional Fishery Bodies (2010)	FAO-001	✓
Statistical Areas for Fishery Purposes (2008)	FAO-003	
Global Distribution of Ports: World Port Index (2011)	NG-AI-001	
Global Distribution of Dive Centres (2001)	WCMC-030	✓
Global Marine Aquarium Database (2003)	WCMC-023	✓

4. Data challenges, gaps and limitations in the marine environment

This section provides a discussion of some of the issues faced when using marine data. The discussion covers topics such as the challenges of marine data collection, the different types of data gaps that exist, and how these challenges are being overcome. The information provided here is intended to introduce the subject rather than present a detailed analysis of the problem.

Background

The ocean covers 71% of the Earth's surface and is host to an estimated 50-80% of all life on Earth. The ocean contains some of the most productive ecosystems, vast natural resources, and unique habitats, and further plays a vital role in regulating the Earth's climate. However, the marine environment is subject to many pressures (UNEP 2006). Fisheries are removing living resources at a rate considered to be unsustainable (Pauly et al. 2002, 2013), while essential habitat is being degraded (by bottom trawling, renewable energy production/extraction infrastructure, underwater cabling, coastal development, aggregate extraction, coastal deforestation, amongst others) and waters are being chemically altered through pollution (including through agriculture runoffs, river discharges and maritime accidents). Furthermore, concern over the impact of climate change on marine ecosystems is increasing (Root et al. 2003), with longer-term shifts in mean environmental conditions and climate variability moving outside the bounds within which adaptations in marine communities have been previously associated (King 2005, Beaugrand 2009). Thus, the changing ocean-atmospheric conditions (including ocean warming and acidification, hypoxia, and ice cover changes) are leading to altered abundances (i.e. population levels) of species, and changing spatial distributions (e.g. Southward et al. 1995, Perry et al. 2005, Beaugrand 2009). In turn, changes at the species level may severely impact the biological and environmental functioning of ecosystems or food webs, the goods and services derived from them, and conservation and resources management.

Why are there data gaps?

Collecting data in the marine environment is challenging

Understanding the impacts of pressures on both marine species and the people that depend on them for food and livelihoods requires substantial data, not only on these species, but also on biogeochemical and oceanographic processes. However, ocean-based research is expensive and logistically challenging due to the size and remoteness of the biomes[11] and to the need for

[11] A biome is a large naturally occurring community of flora and fauna occupying a major habitat (http://www.oxforddictionaries.com/definition/english/biome). Alternative definition at: http://terms.biodiversitya-z.org/terms/29.

advanced technologies and equipment—such as oceanographic research vessels, submersibles, remotely-operated vehicles and remote-sensing (i.e. satellite telemetry, aerial photography)—to gather data in the marine realm. These requirements mean that the costs of marine projects typically exceed those experienced by terrestrial ecologists.

Detailed scientific knowledge is still needed

Despite an estimated 2.2 million species living in the oceans, it is thought that 91% of these have not yet been described (Mora et al. 2011). Gaps in taxonomic expertise further hamper understanding of marine biodiversity and limit the discovery of new species. This is particularly the case for cryptic species, those that are morphologically similar but genetically distinct, and those groups that have a large number of rare or less common species, such as bacteria (Figure 1).

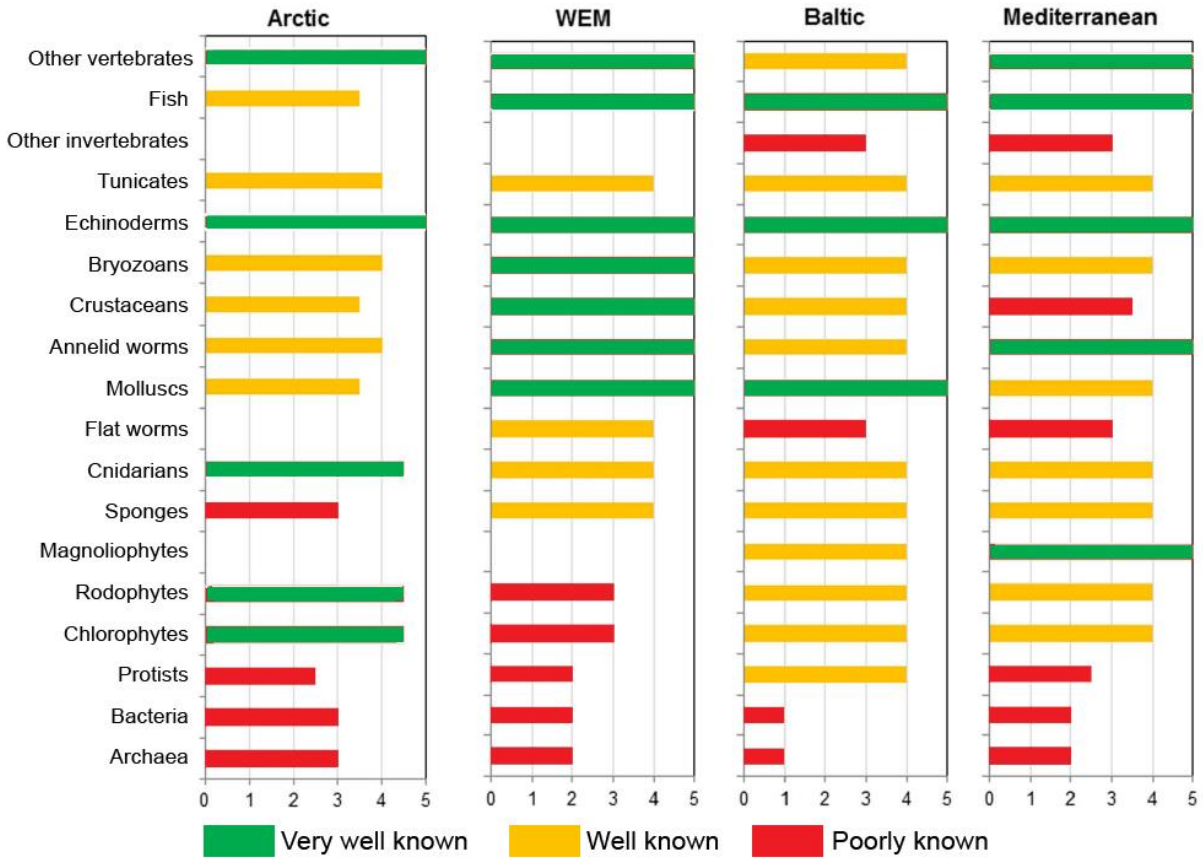


Figure 1[12]. State of knowledge of taxonomic groups ranked from 1 (poorly known) to 5 (very well known) [left blank = not assessed/not applicable] in the Arctic Sea, western European margin (WEM), Baltic Sea and Mediterranean Sea (adapted from: Narayanaswamy et al. 2013). Sources: B. Bluhm pers. Comm.; (Narayanaswamy et al. 2010, Ojaveer et al. 2010, Coll et al. 2010, Danovaro et al. 2010).

Significant time is also needed to carry out adequate species identification, either on research vessels or after the survey for specimens that can be preserved (e.g. eggs/larvae of large species,

[12] Source: http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0058909.

or small species such as invertebrates). Finally, species identification, which includes the description of previously unknown species, usually requires specialist skills (e.g. taxonomy, bioinformatics) and/or equipment (e.g. microscopy, digital imagery analysis, genetic analysis).

Types of data gaps

The challenges associated with collecting and interpreting data on the marine environment therefore often lead to limitations in marine datasets. Accurate, reliable data on the marine environment are frequently scarce, with errors stemming from the low 'detectability' of species[13], species misidentification, and sampling bias[14]. Data frequently show bias in terms of spatial and temporal coverage. For example, if only part of a particular habitat (or environmental gradient) has been sampled for a particular species, spatial coverage is incomplete: this means that observed data on this species may not be a representative sample of locations where that species actually occurs. The following examples illustrate key gaps in data coverage and understanding in the marine environment. These challenges and characteristics should be taken into account when using data to avoid drawing incorrect conclusions.

Spatial and temporal data gaps

It is estimated that 95% of the ocean remains unexplored, with a strong bias in sampling effort and data availability towards temperate regions in the Northern hemisphere, such as the North Atlantic Ocean (Figure 2). In particular, most records for marine species have been obtained from within the exclusive economic zones[15] of Canada, Australia, Alaska, United Kingdom, United States of America, Greenland, Republic of South Africa and Bermuda (Mora et al. 2008). Although tropical areas are known to be species rich, data on the species inhabiting them is amongst the poorest (Mora et al. 2008).

[13] Low detectability in an occupied habitat patch is a common sampling problem when a population size is small, individuals are difficult to sample, or sampling effort is limited (Gu & Swihart 2004).
[14] Sampling bias is consistent error that arises due to a sample not being selected in a random manner.
[15] Exclusive Economic Zones (EEZ) are waters generally up to a distance of 200 nautical miles from a country's coastline.

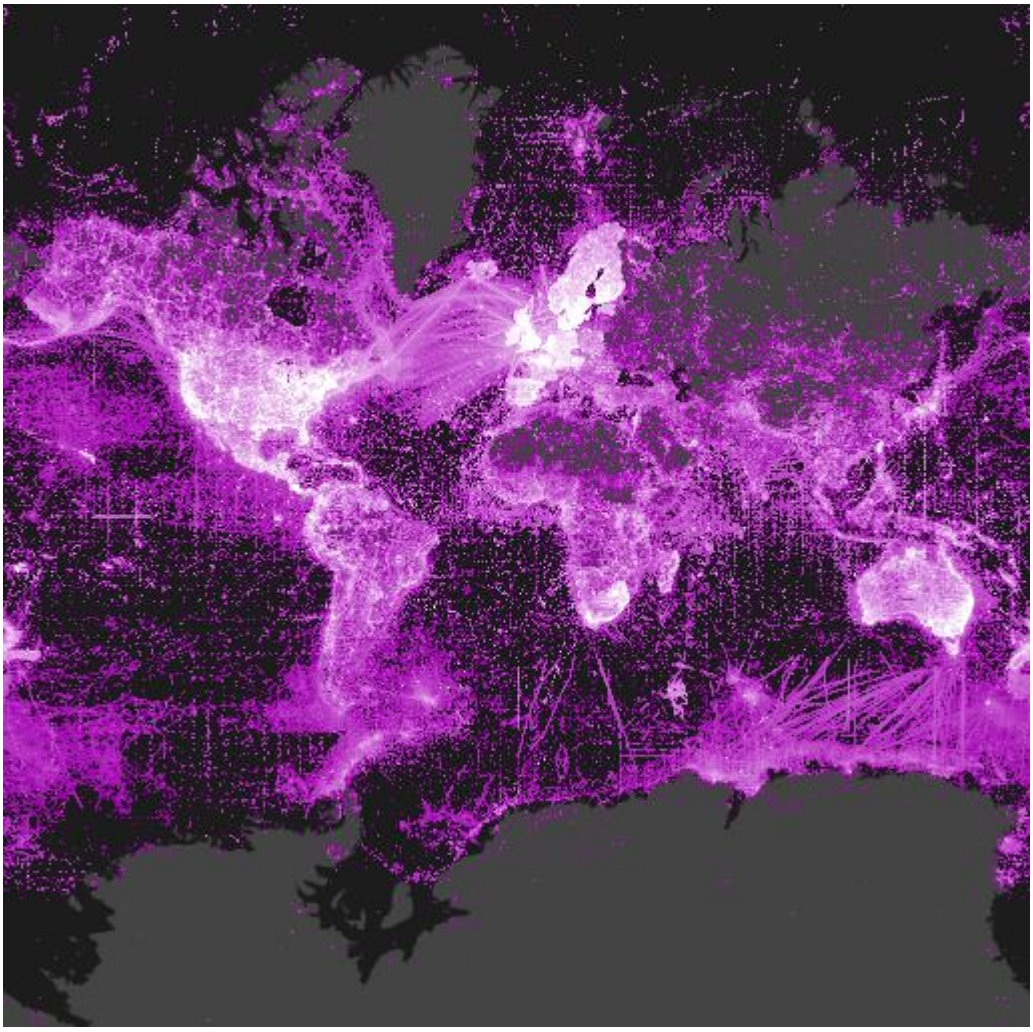


Figure 2[16]. Map showing species occurrence records published in the Global Biodiversity Information Facility (GBIF) network on 30 April 2014 (437 million occurrences from almost 1.5 million species and 602 publishers).

Even within a given animal group, geographic coverage can be heterogeneously distributed. Based on a database of 430 cetacean surveys conducted worldwide from 1975–2005 (Kaschner et al. 2012), Figure 3 illustrates the spatial bias in survey effort, which was found to be mostly concentrated in the northern hemisphere, particularly in waters under US and northern European jurisdiction. This study also showed that, for cetaceans, less than 25% of the world's ocean surface had been surveyed, with almost half the global survey effort (defined as total area, in km², covered by all survey study areas across time) concentrated in the eastern tropical Pacific.

[16] Source: http://www.gbif.org/occurrence.

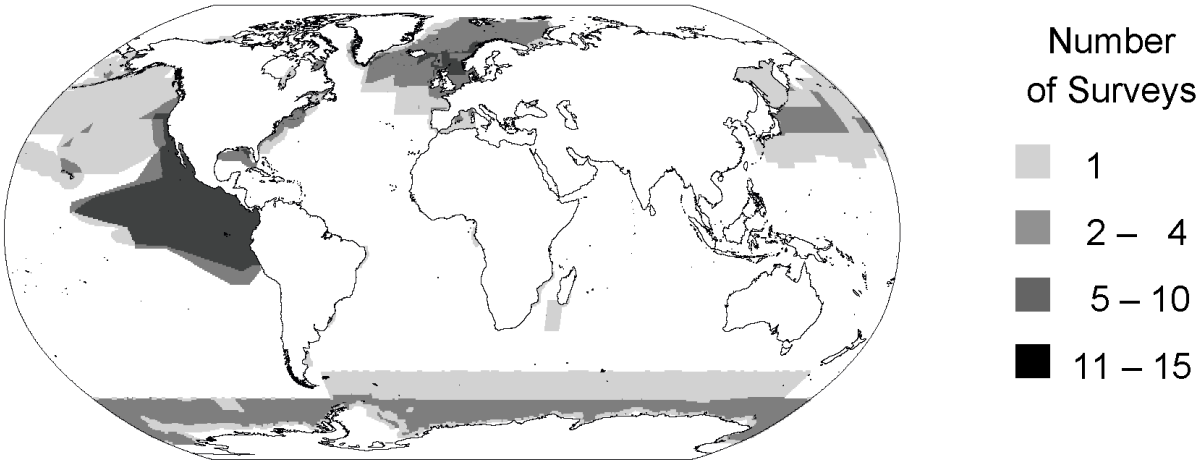


Figure 3[17]. Cetacean line-transect survey effort in terms of frequency of coverage (Kaschner et al. 2012).

Data availability within geographic regions varies considerably depending on the oceanic compartment considered (Figure 4). For example, there are many more records on marine species available from the continental shelf and slope, and from coastal and surface waters, due to their better accessibility and higher productivity. The deep sea and more generally marine areas beyond national jurisdiction remain comparatively unexplored due to the logistical challenges and costs associated with sampling (Mora et al. 2008).

The development status of countries and/or their political stability level can also play a role in the level of sampling in the waters under their jurisdictions. Figure 5 illustrates this for the Mediterranean Sea, where the northwest-southeast divide is highlighted in terms of data gaps for seagrass: most North African countries (except Tunisia) and most eastern European countries (and Turkey) have under-sampled coastlines or coastlines that have not been sampled at all for the species of seagrass considered.

[17] Source: http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0044075

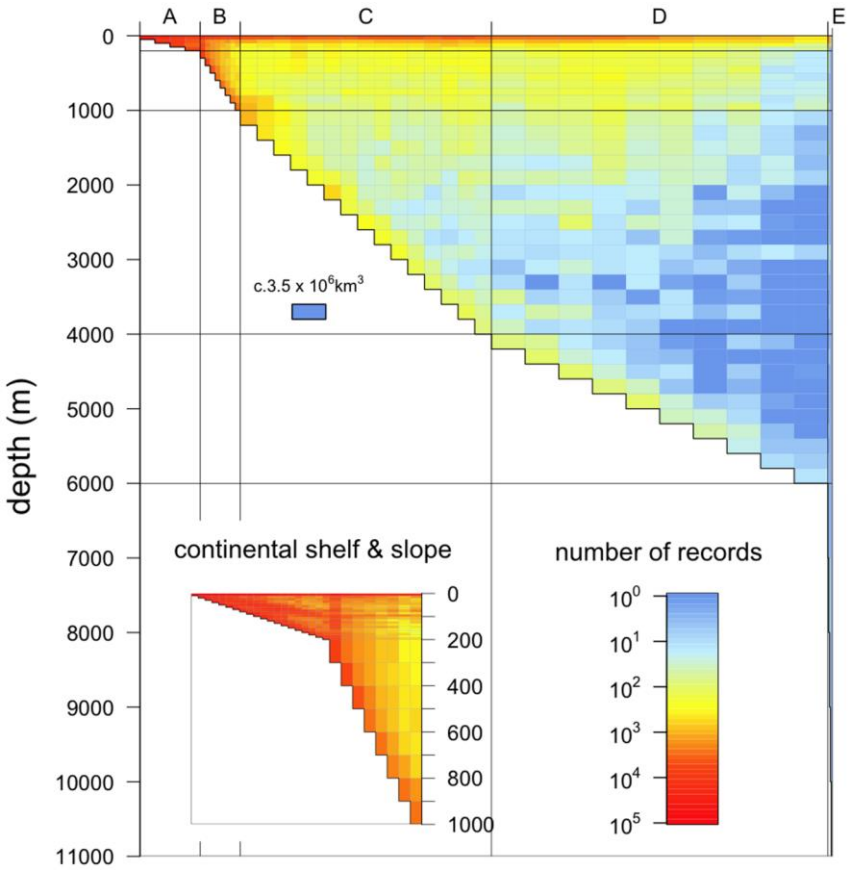


Figure 4[18]. Global distribution within the water column of recorded marine biodiversity (Webb et al. 2010). The horizontal axis splits the oceans into five zones on the basis of depth, with the width of each zone on this axis proportional to its global surface area. The vertical axis is ocean depth, on a linear scale. This means that area on the graph is proportional to volume of ocean. The inset shows in greater detail the continental shelf and slope, where the majority of records are found.

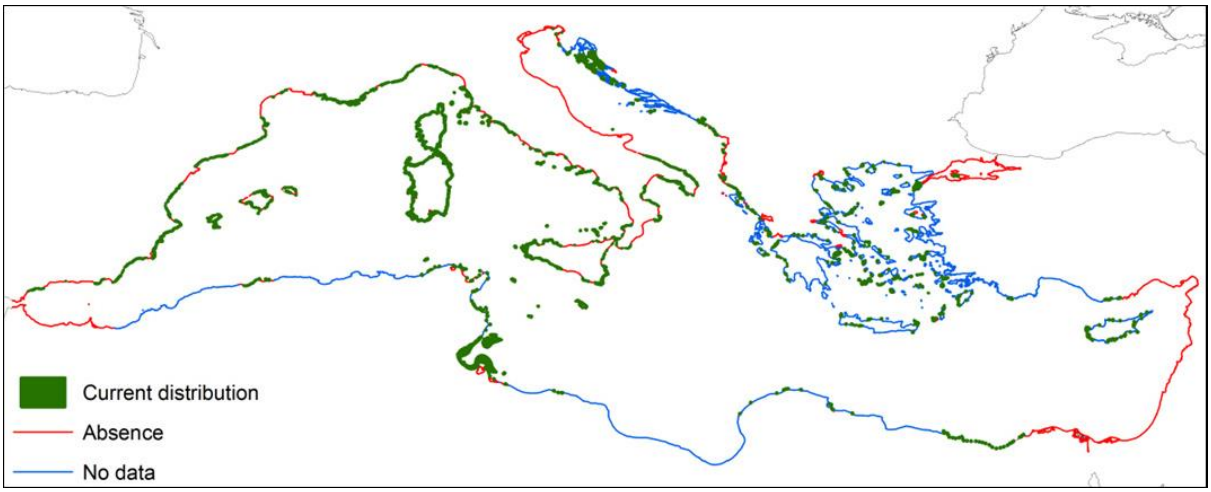


Figure 5[19]. State of knowledge of the distribution of *Posidonia oceanica* seagrass across the Mediterranean Sea (Belluscio et al. 2013), where presence ("current distribution", in green), absence ("absence", in red) and data gaps ("no data", in blue) are shown.

[18] Source: http://www.ploscollections.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0010223
[19] Source: Mediterranean Sensitive Habitats (MEDISEH) project; http://mareaproject.net/contracts/5/reporting/.

Temporal data gaps also exist as exemplified by records from the OBIS-SEAMAP[20] project, which has acquired and served marine mammal, seabird, and sea turtle data to the public since its inception in 2002. Records collected during the autumn and winter were comparatively less frequent than those collected in spring and summer (Figure 6) as a result of temporal sampling bias (Kot et al. 2010).

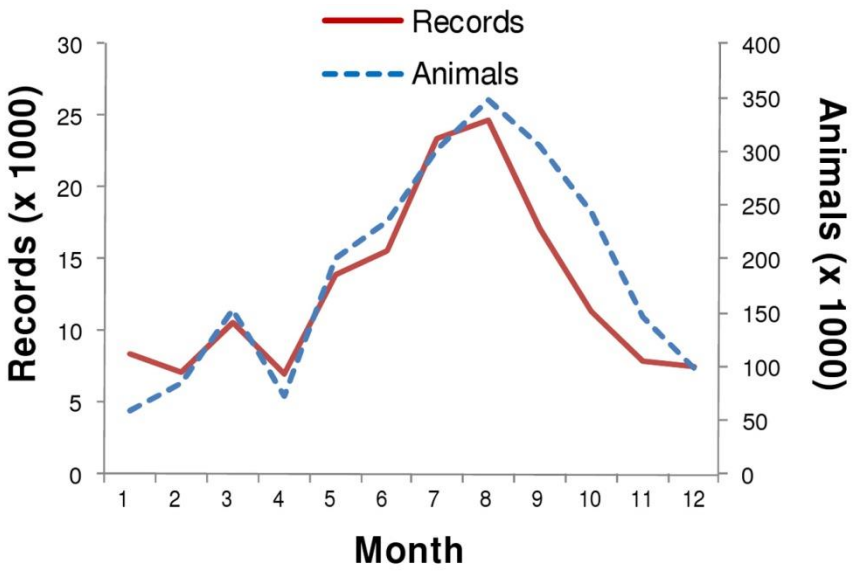


Figure 6[21]. The number of records and animals published on SEAMAP each month for marine mammals (Kot et al. 2010).

Temporal biases in data collection can significantly influence our knowledge of species with seasonal distribution patterns linked to foraging and breeding, for example. If a foraging area is surveyed when such a species has left for its breeding sites, then the data collected would incorrectly suggest that the species is absent from studied area. It should also be noted that datasets compiled from several sources (such as global online data repositories), opportunistically sampled data (such as citizen science programmes, or bird and marine mammal observations on research vessels), and small datasets (such as those for rare or elusive species) are particularly subject to issues of data quality. In these cases, skewed distribution of sampling effort, be it spatially or temporally, may lead to sampling bias, while outlying data points will also contribute large errors to small datasets.

Species data gaps

In addition to the lack of knowledge about marine species there is also a bias in knowledge and data availability of particular animal groups. For example, nearly half of known marine biodiversity is represented by only three groups (crustaceans, molluscs, and fish), and many of these species are commercially important (Intergovernmental Oceanographic Commission

[20] Ocean Biogeographic Information System – Spatial Ecological Analysis of Megavertebrate Populations project; http://seamap.env.duke.edu/.
[21] Source: http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0012990

(IOC) of UNESCO 2014). However, even charismatic marine groups, such as sharks and seahorses, lag behind terrestrial groups in the extent of knowledge on their constituent species and the threats they face. For example, a study found that 31% of sharks, skates and rays and 66% of seahorses lacked sufficient data to undertake an assessment of extinction risk (McClenachan et al. 2012). Deep-sea habitats such as hydrothermal vents and cold seeps are presently under-studied, and so are the plethora of endemic species currently unknown to science that they tend to host.

As of 2013, only 8,171 marine species had been assessed under the IUCN Red List criteria for threatened species (IUCN 2013), i.e. 0.37% of the estimated 2.2 million marine species on the planet. IUCN is not aiming for full assessment of all species on Earth, but rather a representative sample of around 8% of all species (Stuart et al. 2010). Even so, the marine environment is recognised by IUCN to be lagging behind the terrestrial realm and it is a target for further work. Furthermore, although 6,755 (83%) of the assessed marine species have associated expert-derived range maps, these maps do not incorporate information on relative occurrence probability, abundance or ontogeny[22] (this is also the case for terrestrial species). Hence, it is difficult to estimate the likelihood of encounter or population levels in a given location from these maps alone, nor is this their intended use.

Solutions

Addressing spatial and temporal data gaps using models

As a result of the data gaps described above, studies of marine biodiversity and habitats are frequently based on incomplete data, which can lead to skewed or biased interpretation. Consequently, modelling techniques have been developed to improve understanding of distributions and characteristics in the marine environment and the species that inhabit it. A model is a representation of a system, object or event that frequently includes mathematical descriptions and may be used to gain understanding of that system. For example, models representing ecological systems may vary in scale from an individual population, or species, to an ecological community or a climate system. Altering the description of the system by altering the factors, or variables, included in a model allows scientists to explore the system's sensitivity to changes in particular components. This may allow key influencing factors, and the interactions between them, to be determined. Models may be tested and validated by comparing their outputs with observed measurements or the results of repeatable experiments, with lack of agreement frequently leading to model development and refinement as a better understanding of the system being modelled is gained.

[22] Ontogeny related to the origin and development of an individual organism from embryo to adult forms.

Species distribution modelling

Species Distribution Modelling (SDM) techniques (Guisan & Thuiller 2005, Martinez-Meyer 2005, Franklin 2009) have emerged as pragmatic and cost-effective solutions to "filling in" the data gaps mentioned above using predictive mapping. Species distribution models (Figure 7) are based on physical and environmental "predictive" variables (such as water temperature, salinity, seabed type, depth, nutrient concentration) that are typically cheaper and quicker to record and map across vast expanses (i.e. regional seas, global scale) than comprehensive species distributions. Species distribution models associate species presence or density (and where available absence) information with the particular environmental conditions at these locations, thereby indicating the species' preferred range for each predictive variable. By examining the values of each physical and environmental variable at un-sampled locations, a species' potential distribution[23], or range, may then be modelled as the relative suitability of environmental characteristics that would either limit or support it at a particular location. In simple terms, a model predicts the relative probability of occurrence of a species based on the value of environmental and physical variables at that location. A range estimate may thus be obtained for areas that have not been sampled for that species, thereby 'filling in' gaps in knowledge. Modelling is particularly useful for species for which little data are available, although it should be recognised that the quality of the available data may limit the predictive accuracy of the model.

Range predictions, or relative suitability maps can then be validated by retaining some of the species occurrence data for model testing, for example, or by carrying out targeted ground-truthing by using dedicated field surveys. Some models can also be refined using expert opinion, or be updated as more occurrence data become available. Validation procedures assess the level of confidence in model results in lieu of systematic and exhaustive surveys that are rarely a realistic option.

It is worth bearing in mind that while the certainty of the occurrence of a species in a given location cannot be absolute, model outputs can be very informative in providing a gradation of likelihood of occurrence of a species in areas where dedicated field surveys have not yet taken place. For instance, it is possible to delineate the 'core habitat' of a species by retaining only predicted occurrence values above a given threshold, thereby identifying the specific areas where occurrence is predicted to be particularly common. Modelling approaches can also be adjusted to look at seasonality patterns of migratory species, or to identify areas where they congregate.

[23] The *potential* distribution of a species represents areas where a species could be present, due to environmental conditions being suitable for its survival and/or reproduction, but may not actually occur due to for e.g. biotic interactions with other species (such as competition) or depletion of the population through human impacts. This contrasts with the *realised* distribution of a species, which refers to areas where it actually occurs.

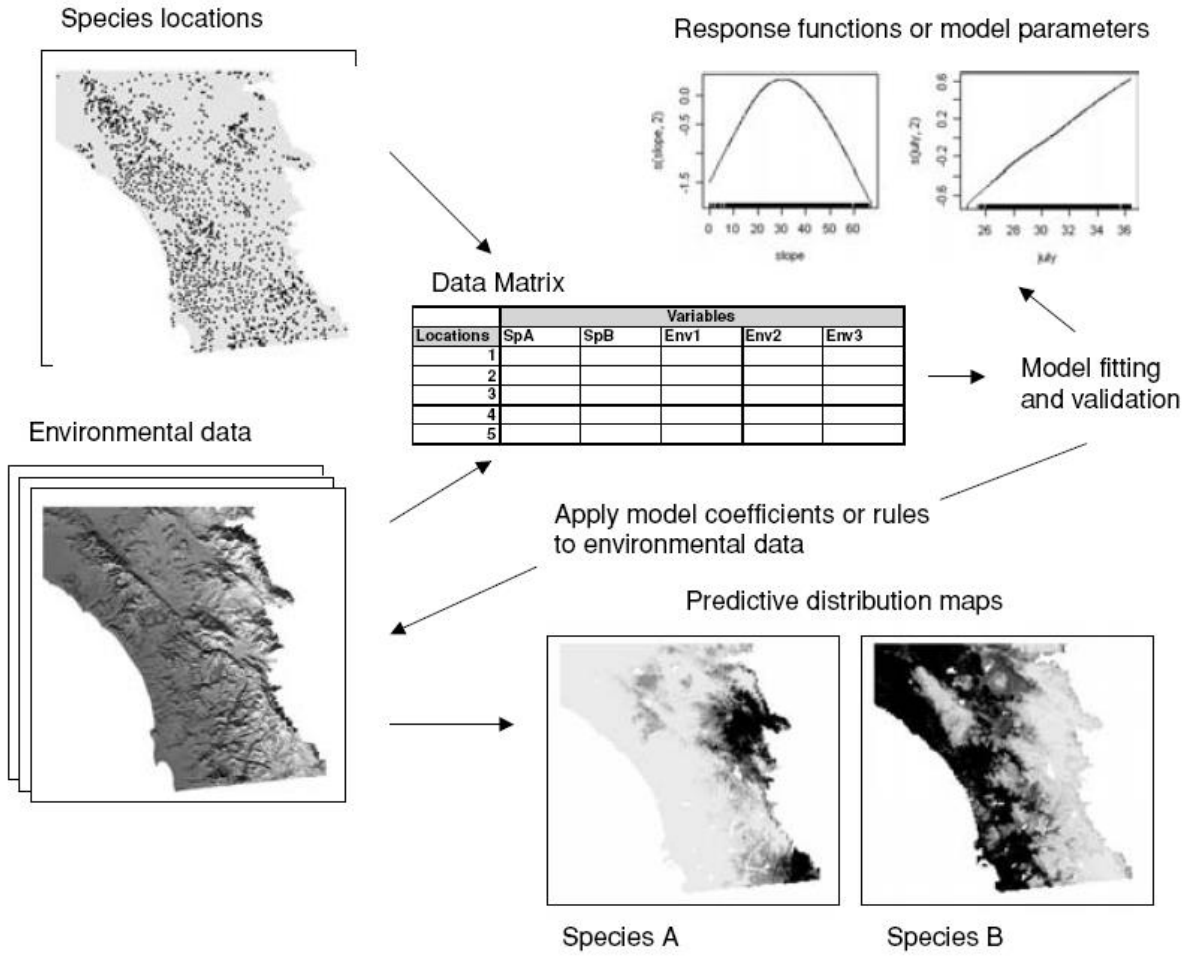


Figure 7. The steps in Species Distribution Modelling (SDM) and predictive mapping (Franklin 2009). Species occurrence data are linked with environmental and physical information, and this relationship is used through modelling to generate continuous distribution maps showing e.g. the relative probability of occurrence of a species across a given area. Image courtesy of Cambridge University Press.

Models can also simulate ecological processes and systems over longer periods of time, or under alternative future scenarios of change from those that are currently observed. A scenario is described as a narrative or storyline that provides a powerful tool in developing an understanding of a range of options or plausible alternative futures (Haward et al. 2012). Rather than focussing on accurate predictions, scenarios enable a variety of futures to be considered and explored (Peterson et al. 2003). For example, scenarios may be developed to assess the potential change in climate resulting from a range of greenhouse gas emissions scenarios, and the resulting changes in species distributions. Models thus enable researchers to simulate large-scale experiments that would be too costly or unethical to perform on a real ecosystem, with the study of inaccuracies allowing hypotheses to be made about possible ecological relations that are not yet known or well understood. Due to the imperfect knowledge of the environment and environmental change in many circumstances, models also aid decision-making and strategic formulation of policies under social and environmental change. Although it is difficult to predict changes in systems under conditions that have not yet occurred, such as under climate change, models may be tested by projecting under previously known conditions (hindcast modelling) or several alternative models may be used to explore and understand the range of uncertainties in model outcomes.

Using data

What does the 'absence of data' mean?

How data are recorded may influence their reliability and subsequent use (e.g. in models, impacts assessments). For example, caution should be taken when using species spatial distributions that have been estimated using data that were not obtained using comprehensive survey and sampling strategies. In this context, it is imperative to discriminate between 'no recorded presence' and 'identified absence'.

During a desktop study (e.g. for an environmental impact assessment), failure to find a record a species at a particular location may mean that:

1. no sampling has taken place at this location;
2. the habitat is not suitable for this species to live, or the habitat is suitable but, due to other factors such as biotic interactions with other species (competition, predation), the species does not generally occupy this habitat;
3. the sampling/survey strategy was not adequate (e.g. wrong time of day for species showing diurnal movements; wrong time of year for species showing seasonal migrations; sampling gear unsuited to the target species, patchy spatial distribution missed by the survey path, etc.);
4. the species was misidentified as another species;
5. the species is rare/elusive, and was therefore not detected, though present; and/or
6. observed data were not shared (e.g. with online databases) or published (in the grey or peer-reviewed literature).

In the marine environment, where detection probabilities are generally low, obtaining valid 'absence data' remains difficult and rare, and observations may therefore represent the minimum area inhabited by a particular species. As a result, species absence records are usually only available at a limited number of sites, because the absence of a species is only ascertained when a given site has been exhaustively explored. Figure 5 presents the result of the collaborative work of over thirty scientists as part of a Mediterranean-wide research project (Giannoulaki et al. 2013). Using available occurrence data from various sources (including published and unpublished observation data) and local expertise on the habitat preference of *Posidonia oceanica*, an endemic species of seagrass, it was possible to create a map showing 'presence' and 'absence' areas for this species across the Mediterranean basin, as well as areas where data were lacking.

Such a "presence-absence" map is infrequent and comparatively more informative than the commonly available "presence-only" maps as it clearly highlights spatial data gaps. The most common form of species data available at large-scale in the marine environment frequently is presence-only data, as exemplified by museum collections and online data repositories, such as the Ocean Biodiversity Information System (OBIS) (Intergovernmental Oceanographic

Commission (IOC) of UNESCO 2014). As Species Distribution Models based on presence-only data are inherently less powerful than those based on presence-absence data, the collection of absence data through systematic surveys should be encouraged.

Data format matters

Marine and coastal datasets exist in numerous formats, and are most commonly distributed as point or polygon vectors (i.e. shapefiles) and rasters (which are grids of pixels of varying resolution), showing areas of presence of species and habitats. As discussed above, information on the real absence of the species or habitat in specific areas (as opposed to the absence of data) is rarely included in the datasets.

The spatial occurrence of species and habitat are often represented using polygon (i.e. boundary) data that show the 'extent of occurrence', i.e. the limits of distribution in a given area. This is different from the 'area of occupancy', which is the fine-scale locations at which a species actually occurs. If, for example, the presence of a species is represented as a set of polygons, and sites within the polygons have in reality only been sparsely sampled, this might obscure the fact that the species is restricted to only a handful of sites within these polygons. In this case, as the species does not occupy all the spaces within the polygons, point data would give a more accurate portrayal of actual occurrence.

When the aim is to calculate the spatial coverage (e.g. surface area in km^2) of a habitat (e.g., seagrass meadows, mangrove forests) in a particular region, polygon data are logically more appropriate than point data, assuming that the habitat is continuously present within the boundary of the polygons. Point locations are however easier to collect than actual boundaries, meaning that point data remain a common data type, even when polygon data would be more appropriate. Some datasets, such as the seagrass layers[24] of the *Ocean Data Viewer*, are hence available as polygons and points, which should be displayed together (Figure 8). Habitats that are difficult to sample such as deep-water vents and seeps are generally available as point datasets. The May 2014 release of the World Database on Protected Areas (IUCN & UNEP-WCMC 2014) had 92% of protected areas as polygons and the remainder (8%) as points. For the latter, it is possible to artificially create a buffer around the point location, based on surface area information (where available), but this cannot be a true representation of the actual protected area boundaries.

[24] http://data.unep-wcmc.org/datasets/7 (points and polygons).

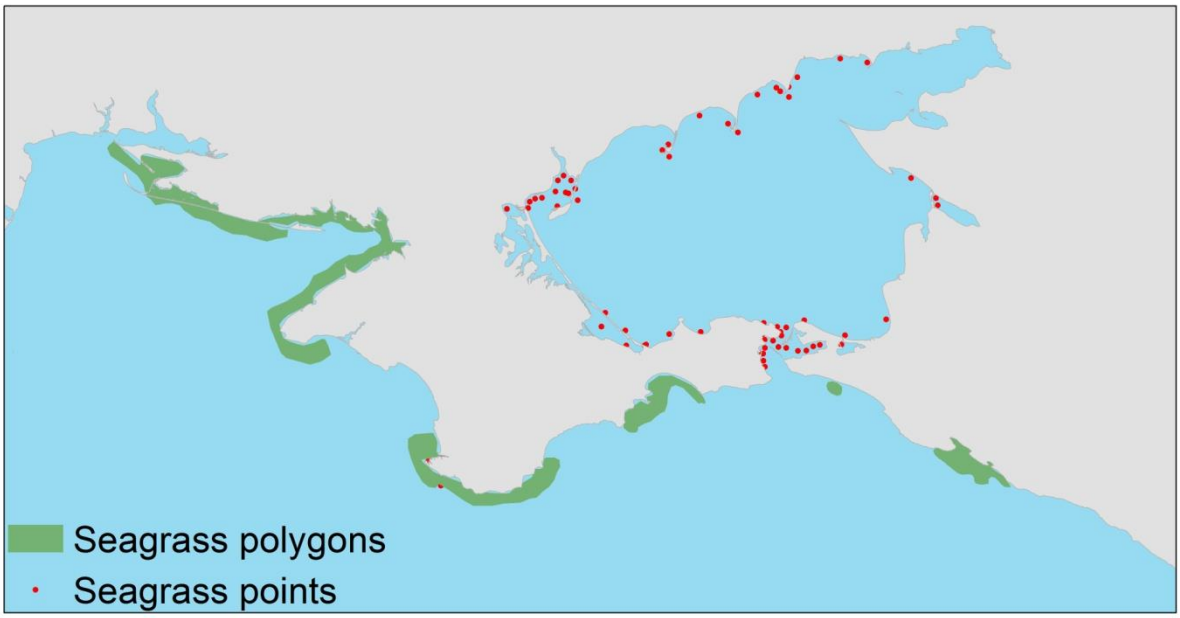


Figure 8. Distribution of seagrasses in the Northern Black Sea region (Green & Short 2003, UNEP-WCMC & Short 2005), illustrating the point and polygon subsets of the dataset.

Spatial and temporal scales of datasets

Another consideration regarding data accuracy and uncertainty is consistency of temporal and/or spatial scales. Data must be available at an appropriate scale to answer a particular question, as patterns observed at one scale (e.g. global, monthly) may not be detectable at another (e.g. local, annual). Different datasets that are combined for an assessment or model must also be at compatible scales. For example, it would be inappropriate to model a species' preferred habitat if species and environmental data were collected in different time periods. If species occurrence data recorded at a fine spatial resolution are combined with sea surface temperature at a much coarser spatial resolution covering a steep environmental gradient, an estimate of preferred temperature range may be much broader than in reality.

Such temporal and spatial mismatches are not infrequent when considering datasets that are particularly time-consuming or expensive to acquire, and therefore are not frequently updated and may not present consistently fine spatial resolutions. Global-scale biodiversity datasets unfortunately often fall in this category, meaning that any use of the data must take into account the age of the dataset.

Understanding the age of the dataset is particularly important for species whose ranges might have shifted through time with temperature patterns, or habitats that might have regressed due to anthropogenic pressure (e.g. pollution) or natural causes (e.g. storms). Consistency of time-scale may thus be particularly important for mobile species with particularly restricted habitat requirements, or for those that show seasonal changes in preferred habitat. Many of the highly migratory baleen whales, such as sei whales (*Balaenoptera borealis*), travel from warm latitude tropical waters in the winter to their feedings grounds in cooler polar waters in the summer. A distribution model based on a mean annual temperature envelope may

therefore be unable to accurately determine the species' regular occurrence in tropical (winter time) and polar (summer time) areas because the whale is found at a wide range of temperatures depending on the season.

Data developments

Despite the uncertainties and knowledge gaps surrounding species and habitats, knowledge of the marine realm is increasing. For example, in 2000, a ten year global scientific partnership was developed to address marine knowledge gaps. This project, the Census of Marine Life[25], involved 2,000 scientists in more than 80 countries worldwide. It was thus able to tackle questions of diversity, distribution and abundance at a global level, establishing a current baseline against which changes could be compared. In addition, the project greatly improved access to data and information on the oceans, as well as tools and capacity for monitoring. The increase in, and collation of, data that the Census of Marine Life contributed also helped researchers and policymakers identify relatively unexplored regions and knowledge gaps.

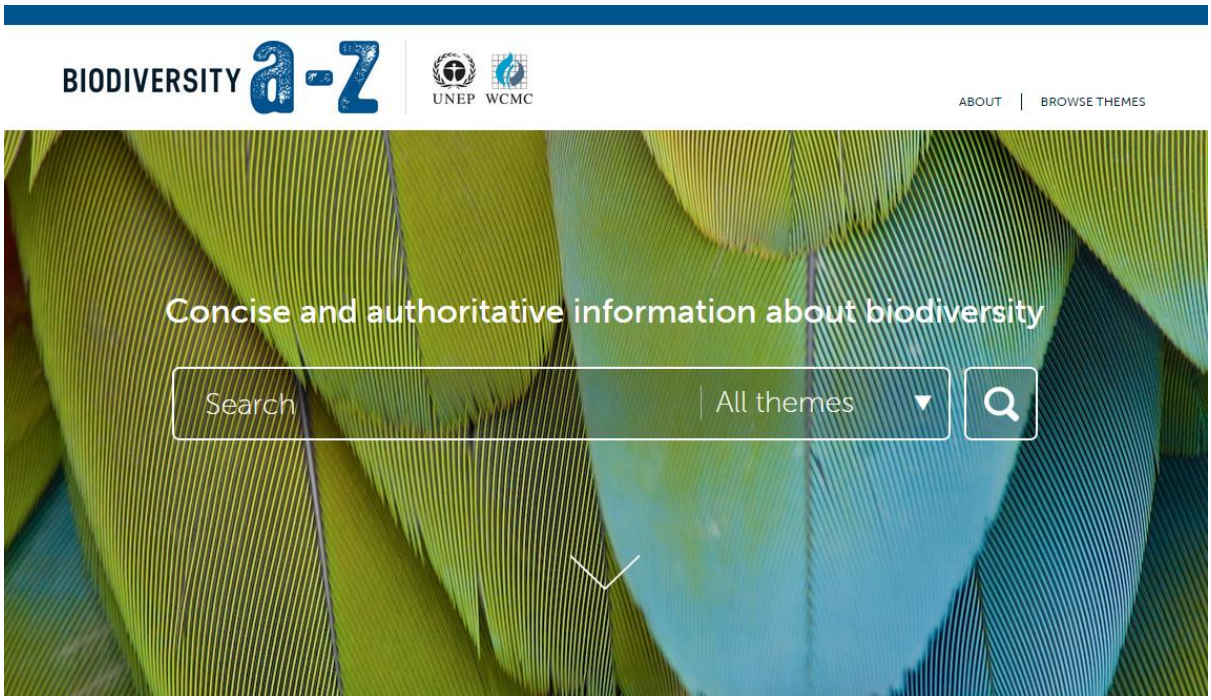
To try to further address some of these gaps, the initiative Life in a Changing Ocean[26] was recently instigated, the goal of which is to advance discovery and expand marine biodiversity knowledge to support healthy and sustainable ecosystems through an integrated global view of marine life. It is hoped that it will address knowledge gaps and answer the questions needed to effectively manage and sustain ocean ecosystems.

Access to data on marine species is further being advanced by online databases such as FishBase[27], SealifeBase[28], OBIS and AquaMaps[29], which make local and regional observation data, species characteristics and life history data and modelled distribution maps available worldwide. Despite these valuable resources, it is likely that much more data exist that were obtained through private funding as part of environmental impact assessments, for example, and are therefore not accessible to the public.

In an environment as extensive, inaccessible and changeable as the global ocean, there will always be gaps in data and knowledge. It is therefore vital that data improvement and provision are encouraged, including through innovative ways such as “citizen science”, whereby the wider public can help collect new data and validate existing datasets. With this aim, UNEP-WCMC has recently produced a habitat validation tool that can be used to ground truth mangrove datasets derived from satellite imagery[30]. Regardless of how data are collected, they must be accompanied by an awareness of their potential uses, limitations and the gaps within them that might affect their reliability and suitability to answer specific questions and promote understanding.

[25] www.coml.org
[26] http://lifeinachangingocean.org
[27] www.fishbase.org
[28] www.sealifebase.org
[29] www.aquamaps.org
[30] http://wcmc.io/bluecarbonvideo.

Annex 1. Background factsheets



Background factsheets are now available on UNEP-WCMC's **Biodiversity A-Z** website (http://biodiversitya-z.org/). The Biodiversity A-Z provides clear, concise and relevant information written and reviewed by experts about various topics related to biodiversity. It is designed to be a useful reference to all sectors, including businesses, governments, and environmental agencies. The content of the Biodiversity A-Z is structured around themes; factsheets on marine and coastal biodiversity features, terminology, and areas are listed under the Marine[31] theme.

[31] http://biodiversitya-z.org/themes/marine?s=home-icons

Annex 2. Dataset summary table

This document offers an overview of data that are of relevance to marine and coastal biodiversity, including those curated or hosted by UNEP-WCMC. To date, 128 datasets, databases, and data portals have been identified, with detailed metadata having been created for 69 of these records (compiled in Annex 3). Coloured shading in the table below are used to indicate that:

- the dataset can be viewed and/or downloaded from UNEP-WCMC's *Ocean Data Viewer*[32],
- more information about dataset access can be sought directly from UNEP-WCMC[33], and
- the dataset is a new addition to the manual (represented by flags).

For all other datasets, information about data layer access can be found in the metadata (if available) or should be sought from the named contact organisation. **UNEP-WCMC does not distribute these datasets and, as conditions may change over time, makes no warranty regarding the accuracy of the information provided in this document.**

Category	Dataset title	Version	Contact organisation	ID[34]	Metadata[35]	Factsheet[36]	Access
Biogenic habitat	Global Distribution of Coral Reefs (2010)	1.3	UNEP World Conservation Monitoring Centre	WCMC-008	✓	✓	Ocean Data Viewer
	Global Distribution of Coral Reefs - 1 Km Data (2003)	7.0	UNEP World Conservation Monitoring Centre	WCMC-009	✓	✓	Contact UNEP-WCMC
	Global Distribution of Cold-water Corals (2005)	2.0	UNEP World Conservation Monitoring Centre	WCMC-001	✓	✓	Ocean Data Viewer
	Global Habitat Suitability for Framework-Forming Cold-Water Corals (2011)	1.0	School of Ocean Sciences, University of Bangor	Bangor-001	✓	✓	Please contact Andrew.J.Davies@bangor.ac.uk and John.Guinotte@marine-conservation.org

[32] http://data.unep-wcmc.org. For commercial use of these datasets, please contact business-support@unep-wcmc.org.
[33] For non-commercial use, please contact marine@unep-wcmc.org; for commercial use, contact business-support@unep-wcmc.org.
[34] Internal UNEP-WCMC numbering system within our metadata catalogue.
[35] Metadata available in Annex 3.
[36] Factsheets available on the Biodiversity A-Z website.

Category	Dataset title	Version	Contact organisation	ID[34]	Metadata[35]	Factsheet[36]	Access
Biogenic habitat	Global Distribution of Habitat Suitability for Stony Corals on Seamounts (2009)	--	UNEP World Conservation Monitoring Centre	WCMC-024		✓	Contact UNEP-WCMC
	Global Distributions of Habitat Suitability for Cold-Water Octocorals (2012)	1.0 (2012)	Institute of Zoology, Zoological Society of London	ZSL-001	✓	✓	Ocean Data Viewer
	Modelled Spatial Distributions of Coralligenous and Maërl Habitats (2014)	2014	UNEP World Conservation Monitoring Centre	Mediseh-001	✓		Contact UNEP-WCMC
	Global Distribution of Mangroves USGS (2011)	1.3 (June 2015)	UNEP World Conservation Monitoring Centre	WCMC-010	✓	✓	Ocean Data Viewer
	Global Spatiotemporal Database of Mangrove Forest Cover (2014)	--	Salisbury University	UniSal-001		✓	Hamilton and Casey (2014)
	World Atlas of Mangroves (2010)	1.0	UNEP World Conservation Monitoring Centre	WCMC-011	✓	✓	Ocean Data Viewer
	Global Distribution of Modelled Mangrove Biomass (2014)	1.0 (2014)	Department of Zoology, University of Cambridge	TNC-001	✓	✓	Ocean Data Viewer
	World Mangrove Atlas (1997)	1.0	UNEP World Conservation Monitoring Centre	WCMC-012	✓	✓	Ocean Data Viewer
	Mangrove Tree Height in Africa (2013)	1.0 (Sept. 2012)	NASA Goddard Space Flight Centre	NASA-001		✓	Contact UNEP-WCMC
	Global Distribution of Seagrasses (2005)	3.0 (Jan. 2015)	UNEP World Conservation Monitoring Centre	WCMC-013-014	✓	✓	Ocean Data Viewer
	Modelled *Posidonia oceanica* Distribution (2013)	2013	Tor Vergata University of Rome	Mediseh-002	✓	✓	Contact UNEP-WCMC
	Global Distribution of Saltmarsh (unpublished)	1.0 (Nov. 2013)	UNEP World Conservation Monitoring Centre	WCMC-027	✓	✓	Contact UNEP-WCMC
Species habitat	Global Distribution of Sea Turtle Nesting Sites (1999)	1.1 (May 2015)	UNEP World Conservation Monitoring Centre	WCMC-007	✓	✓	Ocean Data Viewer

Category	Dataset title	Version	Contact organisation	ID[34]	Metadata[35]	Factsheet[36]	Access
Species habitat	Global Distribution of Sea Turtle Nesting Sites (2011)	--	State of the World's Sea Turtles	SWOT-001		✓	Sea Turtle Status
	Global Distributions of Habitat Suitability for Sea Turtle Nesting Sites (2012)	--	State of the World's Sea Turtles	SWOT-002		✓	Sea Turtle Status
	Global Distribution of Sea Turtle Feeding Sites (1999)	1.1 (May 2015)	UNEP World Conservation Monitoring Centre	WCMC-006	✓		Ocean Data Viewer
	Global Spawning Aggregations Database	--	Science and Conservation of Fish Aggregations	SCRFA-001			Global Spawning Aggregations Database
Species distribution	Data Portal of the Global Biodiversity Information Facility	--	Global Biodiversity Information Facility	GBIF-001			GBIF
	Ocean Biogeographic Information System (OBIS)	--	OBIS Secretariat, Intergovernmental Oceanographic Commission (UNESCO)	OBIS-003	✓		OBIS
	Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations	--	Marine Geospatial Ecology Lab, Duke University	OBIS-004			OBIS-SEAMAP
	Spatial Data for the Red List of Threatened Species	May 2015	International Union for Conservation of Nature	IUCN-001			IUCN Red List
	Corrected and Refined Mangrove Species Ranges (2014)	1.0 (Dec. 2014)	UNEP World Conservation Monitoring Centre	IUCN-002	✓		Contact UNEP-WCMC
	Global Register of Migratory Species (GROMS)	2004	Zoologisches Forschungsinstitut und Museum Alexander Koenig	GROMS-001			GROMS
	AquaMaps: Predicted Range Maps for Aquatic Species (2013)	--	AquaMaps, a joint project of FishBase and SeaLifeBase	AquaMaps-001			Contact UNEP-WCMC
	Global Distribution of Northern Fur Seals (2013)	1.0 (August 2013)	Albert-Ludwigs-University of Freiburg	Kaschner-001	✓		Contact UNEP-WCMC

Category	Dataset title	Version	Contact organisation	ID[34]	Metadata[35]	Factsheet[36]	Access
Species distribution	Global Distribution of Hawaiian Monk Seals (2013)	1.0 (August 2013)	Albert-Ludwigs-University of Freiburg	Kaschner-002	✓		Contact UNEP-WCMC
	Global Distribution of Grey Seals (2013)	1.0 (August 2013)	Albert-Ludwigs-University of Freiburg	Kaschner-003	✓		Contact UNEP-WCMC
	Global Distribution of Hector's Dolphins (2013)	1.0 (August 2013)	Albert-Ludwigs-University of Freiburg	Kaschner-004	✓		Contact UNEP-WCMC
	Global Distribution of Northern Bottlenose Whales (2013)	1.0 (August 2013)	Albert-Ludwigs-University of Freiburg	Kaschner-005	✓		Contact UNEP-WCMC
	Global Distribution of Sperm Whales (2013)	1.0 (August 2013)	Albert-Ludwigs-University of Freiburg	Kaschner-006	✓		Contact UNEP-WCMC
	Global Distribution of Bowhead Whales (2013)	1.0 (August 2013)	Albert-Ludwigs-University of Freiburg	Kaschner-008	✓		Contact UNEP-WCMC
	Global Distribution of Sei Whales (2013)	1.0 (August 2013)	Albert-Ludwigs-University of Freiburg	Kaschner-009	✓		Contact UNEP-WCMC
	Global Distribution of Atlantic Spotted Dolphins (2013)	1.0 (August 2013)	Albert-Ludwigs-University of Freiburg	Kaschner-011	✓		Contact UNEP-WCMC
	Global Distribution of Melon-Headed Whales (2013)	1.0 (August 2013)	Albert-Ludwigs-University of Freiburg	Kaschner-012	✓		Contact UNEP-WCMC
	Global Shark Distribution Database	2009	Dalhousie University	UniDalh-002			Global Shark Distribution Database
	Ocean Tracking Network	--	Dalhousie University	UniDalh-001			Ocean Tracking Network
	Wildlife Tracking	--		SeaTur-001			Wildlife Tracking
	Movebank	--	Max Planck Institute for Ornithology	MovBnk-001			Movebank

Category	Dataset title	Version	Contact organisation	ID[34]	Metadata[35]	Factsheet[36]	Access
Species distribution	Tagging of Pacific Predators in the Pacific Ocean	--	Hopkins Marine Station	TOPP-001			TOPP
Biodiversity metric	Global Patterns of Marine Biodiversity	2010	UNEP World Conservation Monitoring Centre	WCMC-019	✓		Ocean Data Viewer
	Global Map of Shannon's Index of Biodiversity	2014	OBIS Secretariat, Intergovernmental Oceanographic Commission (UNESCO)	OBIS-001	✓		Ocean Data Viewer
	Global Map of Hurlbert's Index of Biodiversity	2014	OBIS Secretariat, Intergovernmental Oceanographic Commission (UNESCO)	OBIS-002	✓		Ocean Data Viewer
	Global Seagrass Species Richness (2003)	1.0	UNEP World Conservation Monitoring Centre	WCMC-015	✓		Ocean Data Viewer
	Global Sea Turtle Species Richness (2002)	--	UNEP World Conservation Monitoring Centre	WCMC-003			Contact UNEP-WCMC
Area of biodiversity importance	Global Distribution of KBAs, IBAs and AZEs	Released several times per year	Birdlife International	Birdlife-001	✓	✓	Contact UNEP-WCMC
	Global Distribution of Vulnerable Marine Ecosystems	2015	Food and Agriculture Organization of the United Nations	FAO-002		✓	Vulnerable Marine Ecosystems Database
	Global Distribution of Ecologically or Biologically Significant Marine Areas	--	Secretariat for the Convention on Biological Diversity (CBD)	CBD-001		✓	Ecologically or Biologically Significant Marine Areas
	Global Distribution of Particularly Sensitive Sea Areas	1.0 (2014)	Claymoreclan Design	IMO-001	✓	✓	International Maritime Organization
	Global 200 Ecoregions	2002	World Wildlife Fund	WWF-001		✓	Global 200
	Areas of Particular Environmental Interest	1.0 (2012)	International Seabed Authority	ISA-001	✓		Contact UNEP-WCMC
	A Global Map of Critical Habitat (2015) as per IFC PS6	1.0 (August 2013)	UNEP World Conservation Monitoring Centre	WCMC-029	✓		Contact UNEP-WCMC

Category	Dataset title	Version	Contact organisation	ID[34]	Metadata[35]	Factsheet[36]	Access
Area of biodiversity importance	Global Diversity Hotspots and Conservation Priorities for Sharks	2011	Dalhousie University	Uni-Dahl-003			Lucifora et al. 2011
	World Database on Protected Areas	Released monthly	UNEP World Conservation Monitoring Centre	WCMC-016	✓	✓	Protected Planet
Biogeographic classification	Global Estuary Database (2003)	2.0 (2014)	Sea Around Us, University of British Columbia	UBC-003	✓		Ocean Data Viewer
	Marine Ecoregions and Pelagic Provinces of the World (2007; 2012)	1.0 (May 2015)	UNEP World Conservation Monitoring Centre	WCMC-036	✓		Ocean Data Viewer
	A Proposed Biogeography of the Deep Oceans	2013	University of Hawai'i	UniHaw-002			Contact watling@hawaii.edu
	Coral Ecoregions of the World	1.0 (2009)	The Nature Conservancy	TNC-003	✓		Contact j.veron@coralreefresearch.com
	Large Marine Ecosystems of the World	July 2013	Large Marine Ecosystem Program, National Oceanic and Atmospheric Administration - Fisheries	NOAA-001	✓		NOAA's LME Portal
	Longhurst Biogeographical Provinces	2006	Flanders Marine Institute	VLIZ-002			Marine Regions
	Geomorphology of the oceans	2014	GRID-Arendal	GridA-001			Blue Habitats
	Global Distribution of Seamounts and Knolls	1.0 (2011)	Institute of Zoology, Zoological Society of London	ZSL-002	✓	✓	Ocean Data Viewer
	Global Seamount Database	2011	School of Ocean and Earth Science and Technology, University of Hawai'i	UniHaw-003		✓	Global Seamount Database
	Global Distribution of Hydrothermal Vents	3.0 (2010)	University of Southampton, National Oceanography Centre	ChEssBase-002	✓	✓	ChEss Database
	Global Distribution of Hydrothermal Vent Fields	3.3 (Oct. 2015)	Woods Hole Oceanographic Institution	IntRid-001	✓	✓	InterRidge Vents Database
	Global Distribution of Cold Seeps	3.0 (2010)	University of Southampton, National Oceanography Centre	ChEssBase-001	✓	✓	ChEssBase
Environmental descriptor	General Bathymetric Chart of the Oceans	2008	British Oceanographic Data Centre	GEBCO-001			GEBCO

Category	Dataset title	Version	Contact organisation	ID[34]	Metadata[35]	Factsheet[36]	Access
Environmental descriptor	Global Sediment Map (marine realm)	7.1	Service Hydrographique et Océanographique de la Marine	SHOM-001			SHOM
	Global Crustal Model	2013	Scripps Institution of Oceanography, University of California	UniCal-002			CRUST
	Global Marine Environmental Dataset	2014	Institute of Marine Science, University of Auckland	GMED-001			GMED
	Bio-ORACLE: a Global Environmental Dataset for Marine Species Distribution Modelling	2012	Phycology Research Group, Ghent University	Ghent-001			Bio-ORACLE
	AquaMaps Environmental Dataset	--	AquaMaps, a joint project of FishBase and SeaLifeBase	AquaMaps-003			AquaMaps
	Mean Sea Surface Productivity in June and December 2003-2007 (2008)	--	UNEP World Conservation Monitoring Centre	WCMC-020-021	✓	✓	Ocean Data Viewer
	Mean Annual Sea Surface Chlorophyll-a Concentration 2009-2013 (2015)	1.0 (April 2015)	UNEP World Conservation Monitoring Centre	WCMC-034	✓	✓	Ocean Data Viewer
	Mean Annual Sea Surface Temperature 2003-2007 (2008)	--	UNEP World Conservation Monitoring Centre	WCMC-022	✓	✓	Ocean Data Viewer
	Mean Annual Sea Surface Temperature 2009-2013 (2015)	1.0 (May 2015)	UNEP World Conservation Monitoring Centre	WCMC-035	✓	✓	Ocean Data Viewer
Ecosystem services and natural capital	Mapping Ocean Wealth	--	Mapping Ocean Wealth, The Nature Conservancy	TNC-004	✓		Mapping Ocean Wealth
	A Global Map of Natural Capital	1.0 (2014)	UNEP World Conservation Monitoring Centre	WCMC-032	✓		UNEP-WCMC
	Marine Ecosystem Services Partnership		Nicholas Institute for Environmental Policy Solutions, Duke University	UniDuke-001	✓		MESP
	A Global Map of Coastal Recreation Values	2013	University of Haifa	UniHaif-001			Ghermandi and Nunes 2013

Category	Dataset title	Version	Contact organisation	ID[34]	Metadata[35]	Factsheet[36]	Access
Ecosystem services and natural capital	Sea Around Us	--	Sea Around Us, University of British Columbia	UBC-009	✓		Sea Around Us
	Ocean Past Initiative	--	Maritime Historical Studies Centre, University of Hull	HMAP-001			HMAP
Ecological status and impact	A Global Map of Human Impacts to Marine Ecosystems	2008	National Centre for Ecological Analysis and Synthesis, University of California	NCEAS-001			NCEAS
	Spatial and temporal changes in cumulative human impacts on the world's ocean	2015	National Centre for Ecological Analysis and Synthesis, University of California	NCEAS-003			Halpern et al. 2015
	Global Data for the Ocean Health Index	2012	National Centre for Ecological Analysis and Synthesis, University of California	NCEAS-002			Ocean Health Index
	Environmental Performance Index	2014	Yale University	Yale-002			EPI
	Living Planet Index	2014	Indicators and Assessments Unit, Zoological Society of London; World Wildlife Fund	WWF-002	✓		LPI Data Portal
	Reefs at Risk	1998	World Resources Institute	WRI-001			Reefs at Risk
	Reefs at Risk Revisited	2011	World Resources Institute	WRI-002			Reefs at Risk Revisited
	Coral Reef Watch	--	National Oceanic and Atmospheric Administration – Fisheries	NOAA-002	✓	✓	Coral Reef Watch
	SeagrassNet: Global Seagrass Monitoring Network	2013	Washington State Department of Natural Resources, Aquatic Resources Division	WaDNR-001	✓	✓	SeagrassNet

Category	Dataset title	Version	Contact organisation	ID[34]	Metadata[35]	Factsheet[36]	Access
	Global Coral Disease Database	1.0 (2010)	UNEP World Conservation Monitoring Centre	WCMC-004			Contact UNEP-WCMC
Ecological status and impact	Fishing Gear Associated with Global Marine Catches	2008	Sea Around Us, University of British Columbia	UBC-008			Sea Around Us
	Global and Regional Assessments of the Marine Environment Database	--	UNEP World Conservation Monitoring Centre	WCMC-038			GRAMED
	Plastic Debris in the Open Ocean	2014	University of Cadiz	UniCadiz-001			Cózar et al. 2014
	Global Restoration Network Database	--	Society for Ecological Restoration	SER-001			GRN Database
	Undersea Cables	--	International Cable Protection Committee	ICPC-001			Interactive submarine cable map
Databases and data portals	Ocean Data Viewer	2015	UNEP World Conservation Monitoring Centre	WCMC-039	✓		Ocean Data Viewer
	Knowledge Network for Biocomplexity (KNB)	--	National Centre for Ecological Analysis and Synthesis, University of California	NCEAS-004	✓		KNB
	PANGAEA	--	Alfred Wegener Institute, Helmholtz Center for Polar and Marine Research	AWI-001	✓		PANGAEA
	FishBase	04/2015	FishBase Consortium	FishBase-001	✓		FishBase
	ReefBase		The WorldFish Center	WorldFish-001			ReefBase
	Map of Life	--	Yale University	Yale-001			MOL
	Global Distribution of Sea Turtles (2010)	--	State of the World's Sea Turtles	SWOT-003			SWOT

Category	Dataset title	Version	Contact organisation	ID[34]	Metadata[35]	Factsheet[36]	Access
Databases and data portals	Environmental Data Explorer	--	United Nations Environment Programme	UNEP-003			Environmental Data Explorer
	UNEP Live	--	United Nations Environment Programme	UNEP-004			UNEP Live
	Atlas of Global Conservation	2014	The Nature Conservancy	TNC-002	✓		Atlas of Global Conservation
	Catalogue of Life	--	Species 2000 Secretariat, Naturalis Biodiversity Center	CoL-001	✓		Catalogue of Life
	World Porifera Database (sponges)	--	Flanders Marine Institute	VLIZ-006			World Porifera Database
	Mangrove Reference Database and Herbarium	--	Flanders Marine Institute	VLIZ-005			Mangrove Reference Database and Herbarium
	Species+	--	UNEP World Conservation Monitoring Centre	WCMC-037			Species+
Administration	Global Self-consistent, Hierarchical, High-resolution Geography Database	2.3.4 (March 2015)	School of Ocean and Earth Science and Technology, University of Hawaii	UniHaw-001	✓		University of Hawai'i
	Global Maritime Boundaries Database	2008	General Dynamics Advanced Information Systems, Inc.	GMBD-001			Global GIS Data Services
	Global Administrative Areas	2.0 (Jan. 2012)	Global Administrative Areas	GADM-001			GADM
	Global Distribution of Islands IBPoW (2010)	1.0	UNEP World Conservation Monitoring Centre	WCMC-005	✓		Contact UNEP-WCMC
	Global Distribution of Islands OSM (2013)	2.0 (2013)	UNEP World Conservation Monitoring Centre	WCMC-031	✓		Contact UNEP-WCMC
	Marine Regions Data Portal	--	Flanders Marine Institute	VLIZ-003			Marine Regions

Category	Dataset title	Version	Contact organisation	ID[34]	Metadata[35]	Factsheet[36]	Access
Administration	Exclusive Economic Zone Boundaries	8.0 (2014)	Flanders Marine Institute	VLIZ-001	✓		Marine Regions
	Regional Seas Boundaries (unofficial)	--	UNEP World Conservation Monitoring Centre	UNEP-002	✓	✓	Contact UNEP-WCMC
	Boundaries of the Global International Waters Assessment	2003	Division of Early Warning and Assessment, United Nations Environment Programme	UNEP-001	✓		GIWA
	Global Distribution of Regional Fishery Bodies (2010)	2010	Food and Agriculture Organization of the United Nations	FAO-001	✓		FAO GeoNetwork
	Statistical Areas for Fishery Purposes	2008	Food and Agriculture Organization of the United Nations	FAO-003			FAO GeoNetwork
	Global Distribution of Dive Centres (2001)	1.2 (June 2015)	UNEP World Conservation Monitoring Centre	WCMC-030	✓		Ocean Data Viewer
	Global Distribution of Ports: World Port Index (2011)	--	National Geospatial - Intelligence Agency	NG-AI-001			National Geospatial - Intelligence Agency
	Global Marine Aquarium Database (2003)	1.0 (2003)	UNEP World Conservation Monitoring Centre	WCMC-023	✓		Contact UNEP-WCMC

Annex 3. Detailed dataset-specific metadata

This annex (distributed separately and previewed in Figure 1 compiles the metadata sheets available to date for 69 datasets. Page numbers within Annex 3 are given overleaf.

The metadata format is based on the metadata database used by the British Geological Survey to meet international spatial metadata standards such as the European INSPIRE Directive or ISO 19115[37].

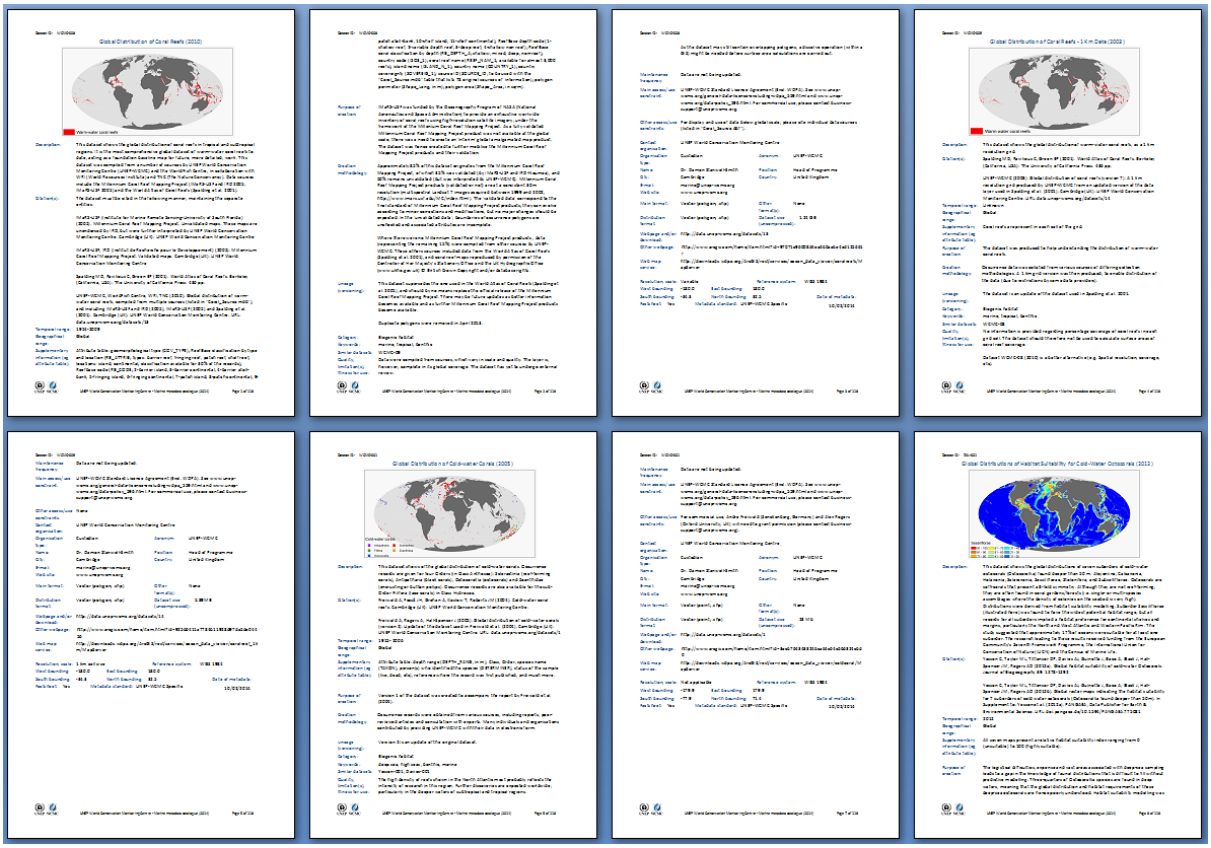


Figure 1. Preview of the separately-distributed annex 3 (185 pp.), which compiles all the dataset-specific metadata sheets available to date.

[37] For further details, see http://www.bgs.ac.uk/downloads/start.cfm?id=2880.

Dataset title	ID[38]	Annex 3
Global Distribution of Coral Reefs (2010)	WCMC-008	p. 1
Global Distribution of Coral Reefs - 1 Km Data (2003)	WCMC-009	p. 5
Global Distribution of Cold-water Corals (2005)	WCMC-001	p. 7
Global Habitat Suitability for Framework-Forming Cold-water Corals (2011)	Bangor-001	p. 9
Global Distributions of Habitat Suitability for Cold-Water Octocorals (2012)	ZSL-001	p. 11
Modelled Mediterranean Coralligenous and Mäerl Distributions (2013)	Mediseh-001	p. 14
Global Distribution of Mangroves USGS (2011)	WCMC-010	p. 17
World Atlas of Mangroves (2010)	WCMC-011	p. 20
Global Distribution of Modelled Mangrove Biomass (2014)	TNC-001	p. 23
Global Distribution of Mangroves (1997)	WCMC-012	p. 26
Global Distribution of Seagrasses (2005)	WCMC-013-014	p. 28
Modelled *Posidonia oceanica* Distribution in the Mediterranean Sea (2013)	Mediseh-002	p. 31
Global Distribution of Saltmarsh (2013)	WCMC-027	p. 34
Global Distribution of Marine Turtle Nesting Sites (1999)	WCMC-007	p. 37
Global Distribution of Marine Turtle Feeding Sites (1999)	WCMC-006	p. 39
Ocean Biogeographic Information System (OBIS)	OBIS-003	p. 41
Corrected and Refined Mangrove Species Ranges (2014)	IUCN-002	p. 44
Global Distribution of Northern Fur Seals (2013)	Kaschner-001	p. 47
Global Distribution of Hawaiian Monk Seals (2013)	Kaschner-002	p. 50
Global Distribution of Grey Seals (2013)	Kaschner-003	p. 53
Global Distribution of Hector's Dolphins (2013)	Kaschner-004	p. 56
Global Distribution of Northern Bottlenose Whales (2013)	Kaschner-005	p. 59
Global Distribution of Sperm Whales (2013)	Kaschner-006	p. 62
Global Distribution of Bowhead Whales (2013)	Kaschner-008	p. 65
Global Distribution of Sei Whales (2013)	Kaschner-009	p. 68
Global Distribution of Atlantic Spotted Dolphins (2013)	Kaschner-011	p. 71
Global Distribution of Melon-Headed Whales (2013)	Kaschner-012	p. 74
Global Patterns of Marine Biodiversity (2010)	WCMC-019	p. 77
Global Map of Shannon's Index of Biodiversity (2014)	OBIS-001	p. 80
Global Map of Hurlbert's Index of Biodiversity (2014)	OBIS-002	p. 82
Global Seagrass Species Richness (2003)	WCMC-015	p. 84
Global Distribution of KBAs, IBAs and AZEs (2013)	Birdlife-001	p. 86
Global Distribution of Particularly Sensitive Sea Areas (2014)	IMO-001	p. 89
Areas of Particular Environmental Interest (2012)	ISA-001	p. 91
A Global Map of Critical Habitat (2015) as per IFC PS6	WCMC-029	p. 93
World Database on Protected Areas (2013)	WCMC-016	p. 96
Global Estuary Database (2003)	UBC-003	p. 100
Marine Ecoregions and Pelagic Provinces of the World (2007; 2012)	WCMC-036	p. 103
Coral Ecoregions of the World (2009)	TNC-003	p. 106
Large Marine Ecoregions of the World (2013)	NOAA-001	p. 108
Global Distribution of Seamounts and Knolls (2011)	ZSL-002	p. 110
Global Distribution of Hydrothermal Vents (2010)	ChEssBase-002	p. 113
Global Distribution of Hydrothermal Vent Fields (2013)	IntRid-001	p. 116
Global Distribution of Cold Seeps (2010)	ChEssBase-001	p. 119

[38] Internal UNEP-WCMC numbering system as part of our metadata cataloguing.

Dataset title	ID[38]	Annex 3
Mean Sea Surface Productivity in June and December 2003-2007 (2008)	WCMC-020-021	p. 122
Mean Annual Sea Surface Chlorophyll-a Concentration 2009-2013 (2015)	WCMC-034	p. 124
Mean Annual Sea Surface Temperature 2003-2007 (2008)	WCMC-022	p. 127
Mean Annual Sea Surface Temperature 2009-2013 (2015)	WCMC-035	p. 129
Mapping Ocean Wealth	TNC-004	p. 131
A Global Map of Natural Capital (2014)	WCMC-032	p. 134
Marine Ecosystem Services Partnership	UniDuke-001	p. 136
Sea Around Us	UBC-009	p. 138
Living Planet Index Database	WWF-002	p. 141
SeagrassNet: Global Seagrass Monitoring Network (2013)	WaDNR-001	p. 144
Ocean Data Viewer	WCMC-039	p. 146
Knowledge Network for Biocomplexity (KNB)	NCEAS-004	p. 149
PANGAEA	AWI-001	p. 152
FishBase	FishBase-001	p. 155
Atlas of Global Conservation	TNC-002	p. 157
Catalogue of Life	CoL-001	p. 159
Global Self-consistent, Hierarchical, High-resolution Geography Database (2013)	UniHaw-001	p. 163
Global Distribution of Islands IBPoW (2010)	WCMC-005	p. 166
Global Distribution of Islands OSM (2013)	WCMC-031	p. 169
Exclusive Economic Zone boundaries (2012)	VLIZ-001	p. 171
Regional Seas Boundaries (unofficial)	UNEP-002	p. 174
Boundaries of the Global International Waters Assessment (2003)	UNEP-001	p. 176
Global Distribution of Regional Fishery Bodies (2010)	FAO-001	p. 178
Global Distribution of Dive Centres (2001)	WCMC-030	p. 181
Global Marine Aquarium Database (2003)	WCMC-023	p. 183

Annex 4. Marine mammal maps (K. Kaschner/AquaMaps)

Introduction

The information presented in this annex is the result of a collaboration between UNEP-WCMC and marine mammal expert Dr. Kristin Kaschner (Aquamaps; Albert-Ludwigs-University of Freiburg, Germany). Through this collaboration, modelled data layers on the spatial distributions of three pinnipeds and seven cetaceans (Table 1) were prepared. These species were selected so as to produce a representative sample of the following:

- range of IUCN conservation statuses (IUCN 2012),
- quality of predictions using the AquaMaps modelling approach,
- availability of independent datasets for comparison with the AquaMaps predictions,
- size of spatial distributions.

Table 1. Marine mammal species for which spatial data layers were obtained from Dr. Kristin Kaschner. The conservation status is according to IUCN (2013): CR – critically endangered; EN – endangered; VU – vulnerable; LC – least concern; DD – data deficient). *: Atlantic stock is CR. The availability of metadata (compiled in annex 3) is indicated (✓).

Group	Common name	Scientific name	IUCN status	Spatial data	Metadata
Pinniped	Northern fur seal	*Callorhinus ursinus*	VU	Annual map	✓
	Hawaiian monk seal	*Monachus schauinslandi*	CR	Annual map	✓
	Grey seal	*Halichoerus grypus*	LC	Annual map	✓
Cetacean	Hector's dolphin	*Cephalorhynchus hectori*	EN	Annual map	✓
	Northern bottlenose whale	*Hyperoodon ampullatus*	DD	Annual map	✓
	Sperm whale	*Physeter macrocephalus*	VU	Annual map	✓
	Bowhead whale	*Balaena mysticetus*	LC*	Annual map	✓
	Sei whale	*Balaenoptera borealis*	EN	Annual map	✓
	Atlantic spotted dolphin	*Stenella frontalis*	DD	Annual map	✓
	Melon-headed whale	*Peponocephala electra*	LC	Annual map	✓

The general idea behind this collaboration was to go beyond traditional expert-derived range maps, such as those provided by the IUCN[39] (IUCN 2013). Such manually- or expert-delineated maps depict the whole range of individual species, without highlighting where the species in question is more or less likely to be found. These types of range maps are often fairly subjective and delineation may vary between different experts. Furthermore, the underlying rationale for selecting boundaries is generally not transparent and hence difficult to reproduce.

In the present piece of work, a numerical model was used to produce outputs based on a clearly defined set of assumptions, and a transparent approach utilising as input (i) available occurrence data and (ii) information about species habitat usages (including expert-knowledge). In addition to delineating reproducible range extents, these predictions also

[39] 2013 Red List Spatial Data; http://www.iucnredlist.org/technical-documents/spatial-data.

provided information on the relative probability of occurrence of selected marine mammal species, throughout their respective ranges. From the numerical model outputs, the known and probable global distributions were derived. The maps were then expert-reviewed and validated to the extent possible.

The AquaMaps approach (general methodology)

Aquamaps (Kaschner et al. 2014) is an online species distribution model that allows the generation of standardised digital range maps of aquatic species, and currently covers more than 17,000 species. Maps are generated using a modified version of the Relative Environmental Suitability (RES) model developed by Kaschner et al. (2006), which uses available information about habitat usage of a given species, projected into geographic space, to help visualise its distribution. Habitat usage is quantitatively described with the help of so-called environmental envelopes defining a species' preference with respect to a set of pre-defined environmental conditions, including:

- depth;
- sea-ice concentration;
- temperature;
- salinity; and
- primary production.

By default, envelopes are derived from occurrence records available through the Global Biodiversity Information Facility[40] (GBIF) supplemented by additional information obtained through online species databases such as FishBase[41] and SeaLifeBase[42]. Acknowledging the sampling biases of currently available online occurrence data, however, AquaMaps explicitly also allows for experts to review and modify environmental envelopes manually.

Map outputs represent annual average predictions of the maximum range extent of species (defined as the maximum area between the known outer-most limits of a species' regular or periodic occurrence) and gradients of relative habitat suitability or species occurrences (ranging from 0 to 1), predicted for each 0.5 degree latitude by 0.5 degree longitude cells. Predictions represent a visualisation of the basic environmental niche of a species, which may often be closer to the historic occurrence of species or its potential niche rather than its realised or currently occupied niche. Binary range maps corresponding more closely to areas of known occurrence may be derived using presence thresholds ideally defined by validation analysis (Kaschner et al. 2011)(see below).

[40] GBIF (www.gbif.org)
[41] www.fishbase.org
[42] www.sealifebase.org

AquaMaps predictions for different species have been validated using independent datasets (Kaschner et al. 2006, 2011, Ready et al. 2010) and generally capture existing knowledge of large-scale and long-term annual average species occurrence reasonably well. However, given the overall paucity of data and the frequently large sampling biases in the marine environment, produced outputs should be regarded as hypotheses of species occurrence, based on a clearly defined set of documented and transparent assumptions that can be tested and further refined as new data become available. Moreover, since marine mammal habitat usage often varies across seasons and ocean basins, global predictions should not be used without further review to describe regional species occurrence (and should ideally be checked against independent data) and the overall limitations of data availability, model biases and assumptions, etc., should be kept in mind when using produced outputs for management purposes.

Specific methodology for generating updated annual average maps

Expert-review was based on environmental envelopes computed from the most recent AquaMaps harvest of occurrence data from GBIF in August 2013. For each species, point occurrence records and resulting 0.5 degree presence cells were reviewed to exclude false records (species misidentifications, fossil records and outliers) based on a comparison of published information about species distributions including, but not limited to, IUCN individual species pages (IUCN 2013). Calculated envelopes based on the final subset were further reviewed to ensure that these matched available information about habitat usages as published in the literature. Predictions about the relative probability of occurrence /habitat suitability were then generated based on these reviewed envelopes. Finally, the resulting predictions were reviewed by comparing them with existing information about the maximum range extent and relative occurrence of species within that range, highlighting both false predicted presences and absences.

Quality of predictions is reflected in the assigned rank (1 = worst to 5 = best[43]) associated with all outputs. It should be noted that the top two ranks are only assigned if predictions have been successfully and quantitatively validated using independent effort-corrected survey data throughout the whole range ("5") or for at least part of the species range ("4") and as the time available for this project was insufficient for conducting these types of validation, the top rank assigned was a "3" (with the exception of sperm whales for which a quantitative validation had been carried out using data from Antarctic waters).

Presence threshold to be used for producing binary[44] range maps

Validation analyses have shown strong correlations between observed relative species occurrence and predicted relative environmental suitability as predicted by RES[45] and

[43] http://www.aquamaps.org/rating.html
[44] i.e. presence/absence.
[45] Relative Environmental Suitability.

AquaMaps for the majority of species and areas with enough data from large-scale, long-term dedicated marine mammal surveys to allow testing (Kaschner et al. 2006, 2011, Ready et al. 2010). Observed species densities tend to be highest in areas of predicted relative probability > 0.4 to 0.6, and validation analysis indicated that this is the most likely presence threshold that should be used to produce the most likely representation of known and probable occurrence of the species, although this may vary for different species[46]. The threshold recommended in the individual species files are based on a precautionary approach that should be used in light of existing uncertainties and in the context of environmental impact assessment.

Mapped predictions

Figures 1 to 10 show the modelled distribution maps for all ten species considered here.

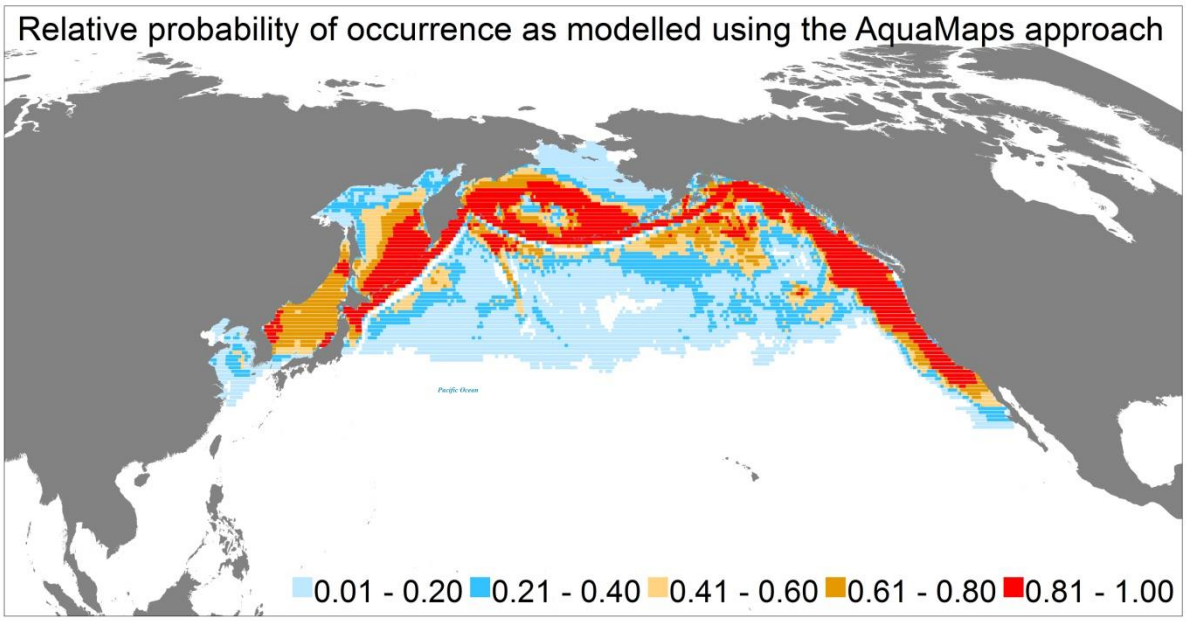


Figure 1. Modelled distribution map for the northern fur seal.

[46] Please refer to dataset-specific metadata.

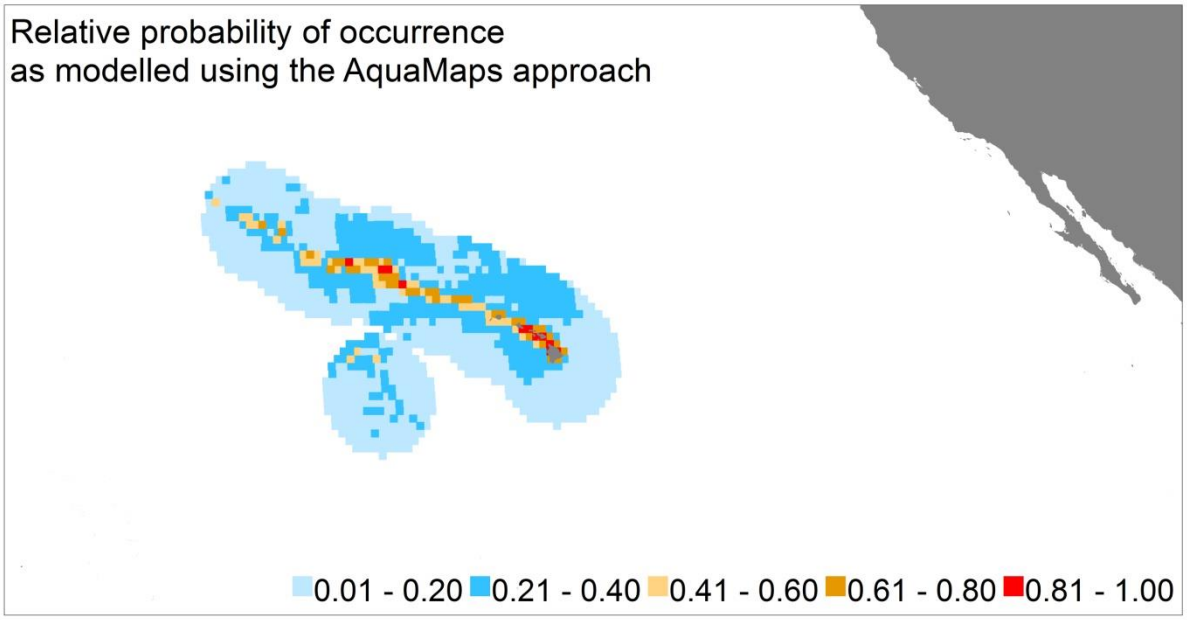


Figure 2. Modelled distribution map for the Hawaiian monk seal.

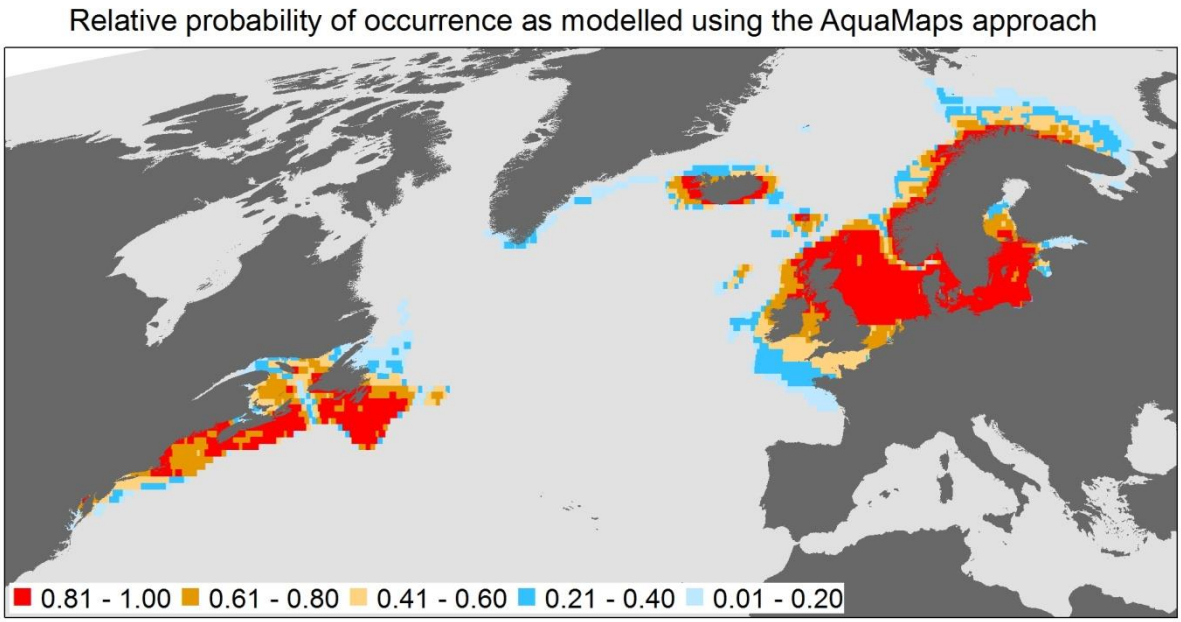


Figure 3. Modelled distribution map for the grey seal.

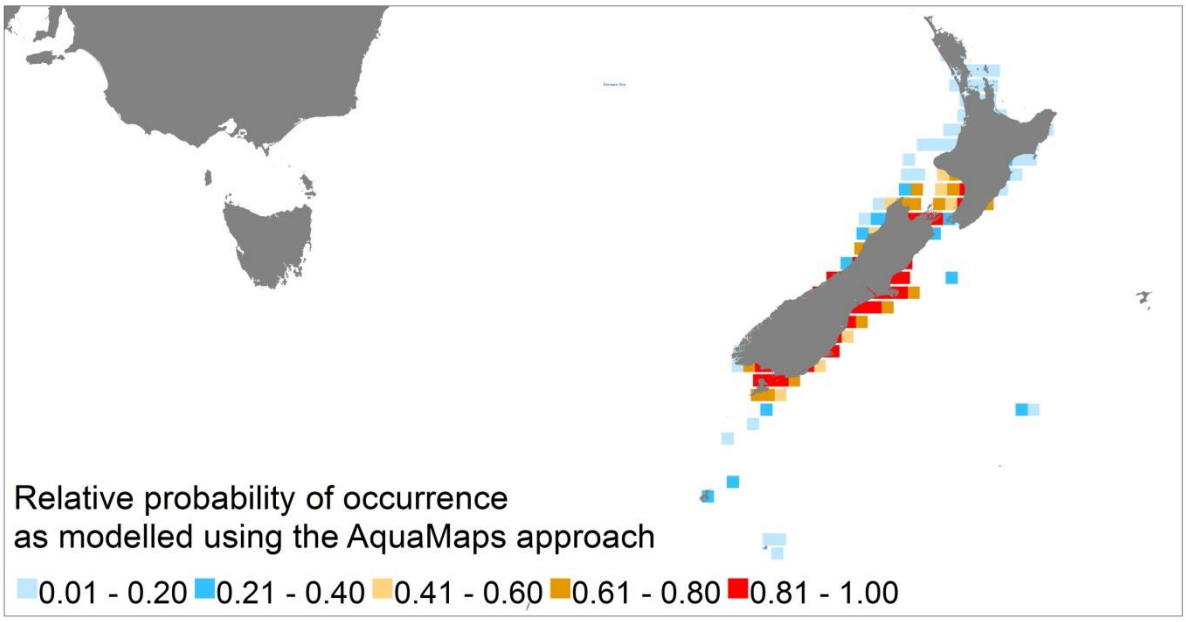


Figure 4. Modelled distribution map for Hector's dolphin.

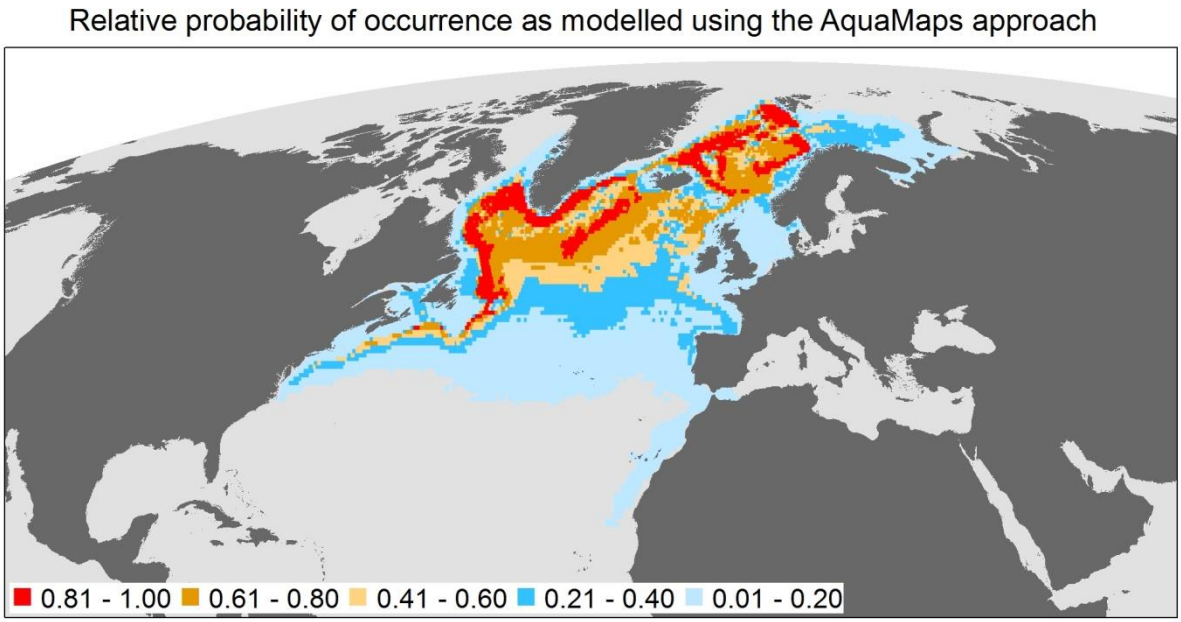


Figure 5. Modelled distribution map for the northern bottlenose whale.

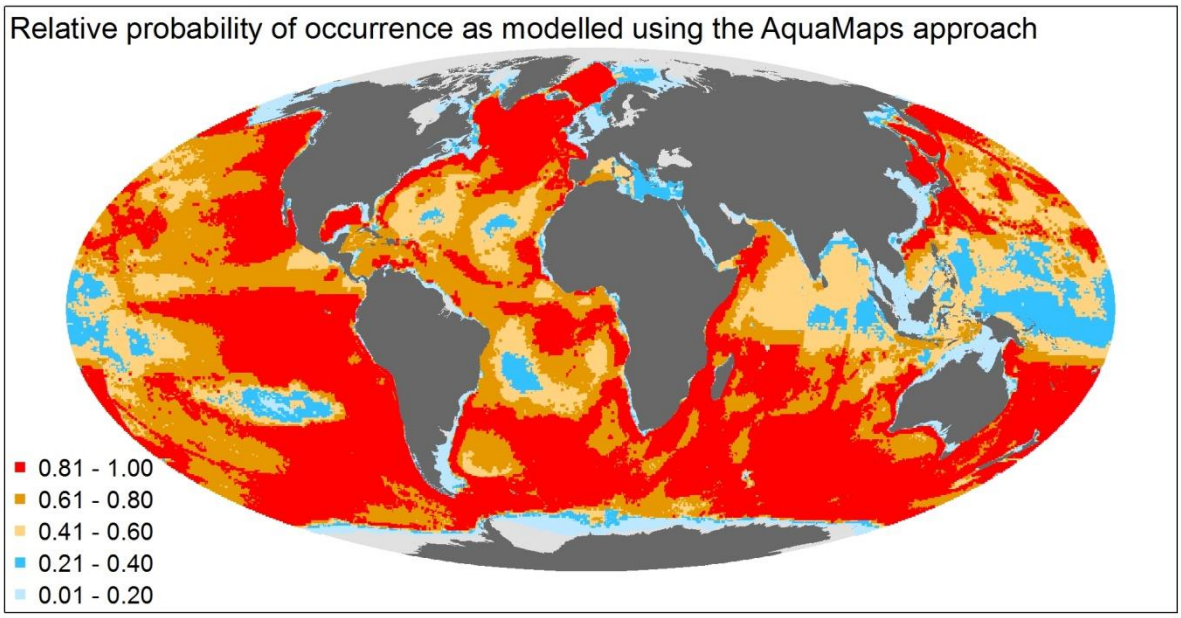


Figure 6. Modelled distribution map for the sperm whale.

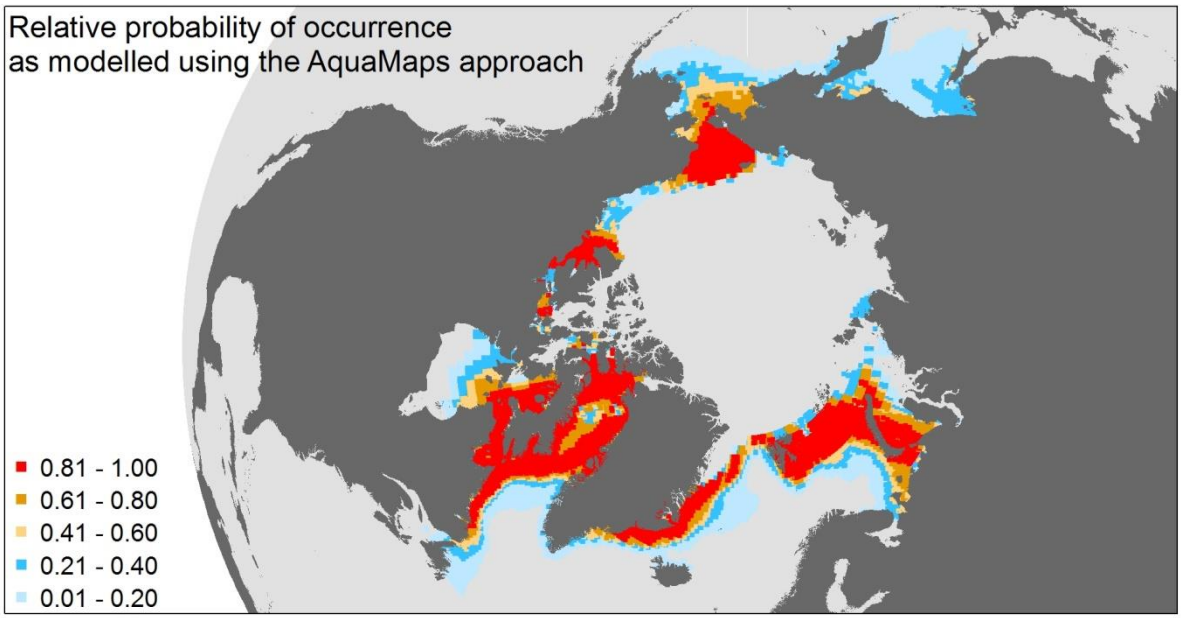


Figure 7. Modelled distribution map for the bowhead whale.

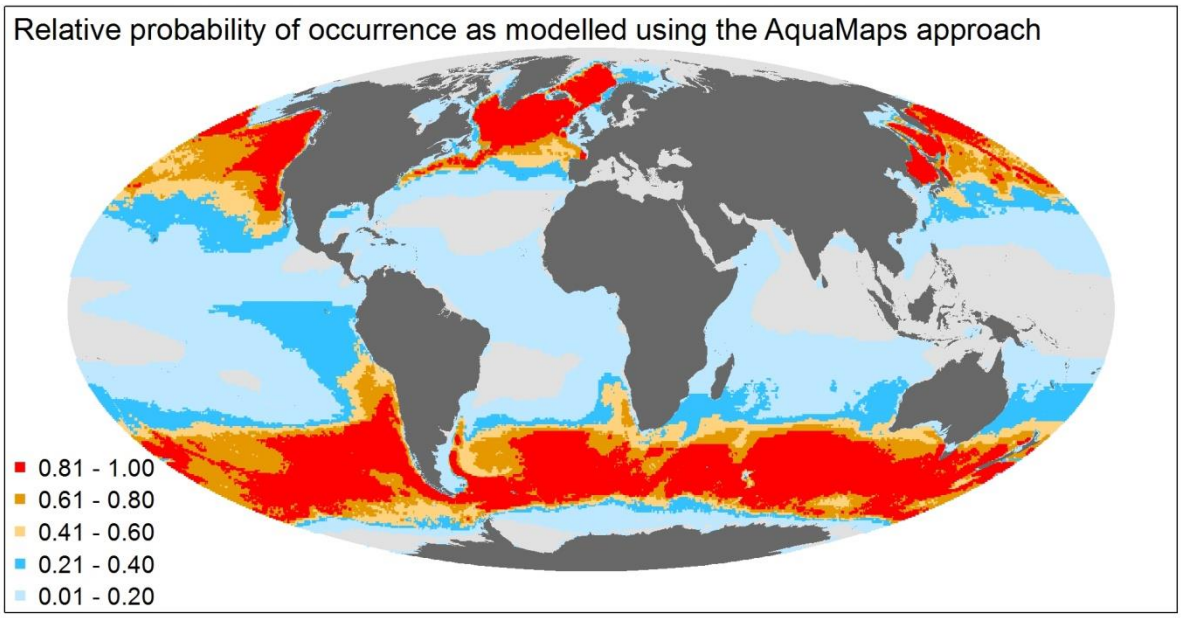


Figure 8. Modelled distribution map for the sei whale.

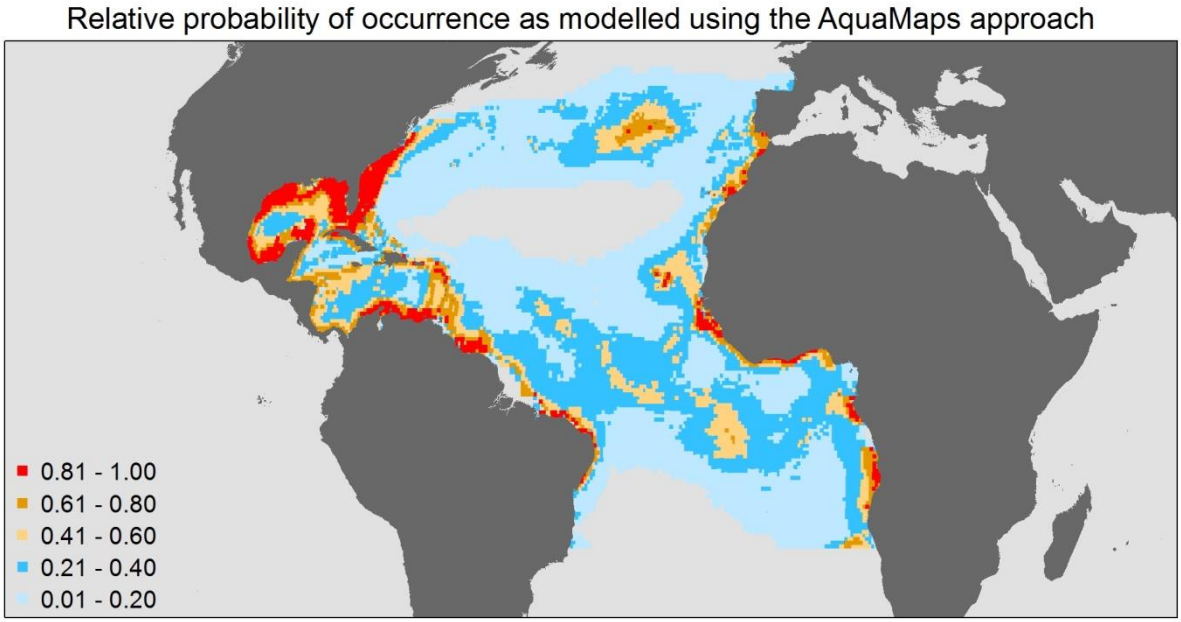


Figure 9. Modelled distribution map for the Atlantic spotted dolphin.

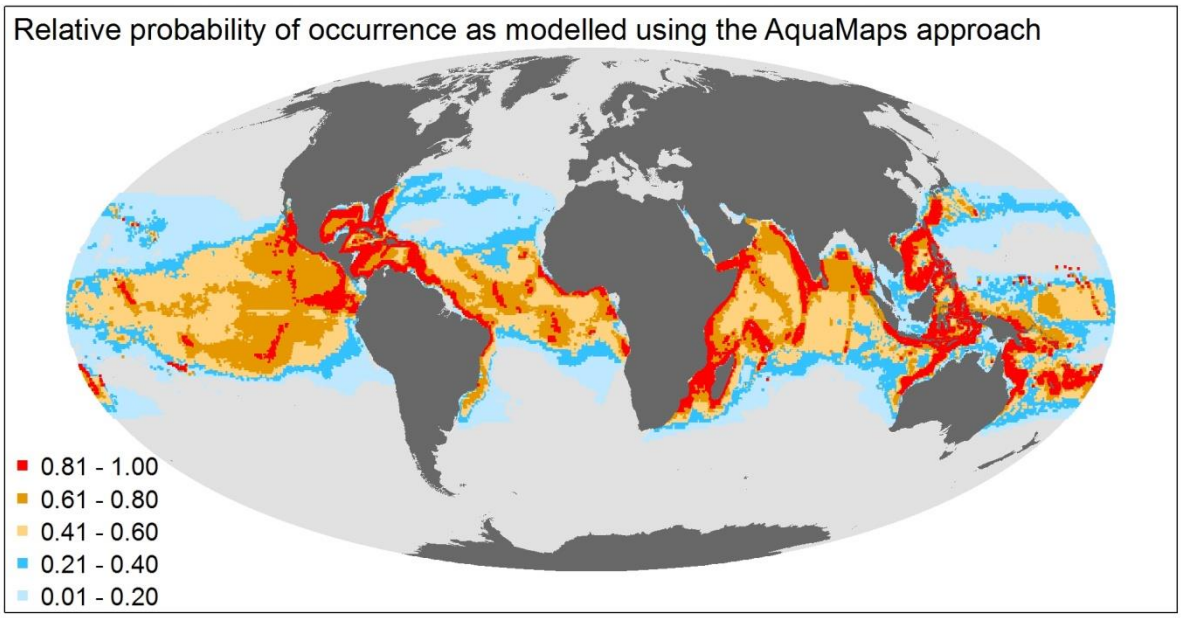


Figure 10. Modelled distribution map for the melon-headed whale.

All ten maps can also be viewed in an 'interactive PDF' (in e-supplement to this annex, and previewed in Figure 11) and on the *Ocean Data Viewer*[47]. For accessing the actual data layers (i.e. shapefiles), please refer to the metadata.

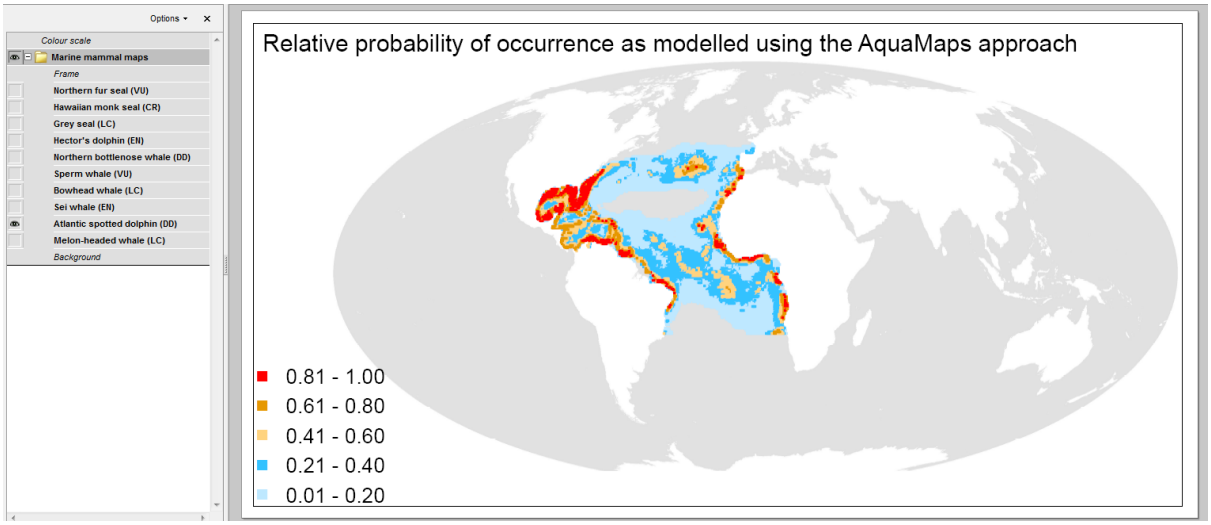


Figure 11. Preview of the interactive PDF (e-supplement) showing distribution maps for ten marine mammal species.

[47] http://data.unep-wcmc.org/.

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