Supplementary Materials

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Digital map of the Coral Triangle: An online atlas for marine biodiversity conservation

1. Documentation file

This documentation file of the Coral Triangle Digital Map provides information on the map objectives, datasets, dataset sources, classifications, and original citations of the data sources. This file can be accessed from: *https://sites.google.com/view/coral-triangle-digital-map.*

1.1. Coral Triangle – General Information

The "*Digital Map of the Coral Triangle"* consists of three sets of web-mapping applications: (1). Biodiversity Features, (2) Areas of Importance for Biodiversity Conservation, (3) Marine Protected Area (MPA) Network Expansion.

The first map, Biodiversity Features, provided comprehensive data on the region's marine protected areas and biodiversity features including biogenic habitat, habitat rugosity, species richness, distribution of threatened and endemic species, and areas important for sea turtles. This tool also provided datasets of threats to the marine environment (anthropogenic and climate change induced pressure), and of environmental characteristics of the region including physical and biochemical oceanography.

The second map, Areas of Importance for Biodiversity Conservation, comprised of two layers: (1) regional biodiversity hotspots, and (2) Sites of biodiversity importance. Each layer was developed based on the multi-criteria analysis of five ecological criteria, namely sensitive habitat, species richness, the presence of species of conservation concern, the occurrence of restricted-range species, and areas of importance for particular life history stages of species.

The third map, Marine Protected Area (MPA) Network Expansion, consisted of two datasets: (1) Regional priority areas, and (2) National priority areas. The map was developed using conservation prioritization tools based on seven different sets of biodiversity features (biogenic habitat, habitat rugosity, species richness, distribution of threatened and endemic species, areas important for sea turtle), two types of threat (anthropogenic and climate change induced pressure) and the coverage of the existing MPA network.

The Digital Map of the Coral Triangle presents representative information to support a better understanding of important areas for biodiversity conservation and the application of marine biodiversity informatics to aid conservation prioritization.

1.2. Digital Map of the Biodiversity Features in the Coral Triangle

These maps provide comprehensive data on the region's marine protected areas and biodiversity features including biogenic habitat, habitat rugosity, species richness, distribution of threatened and endemic species, areas important for sea turtle. This tool also provides a dataset of threats to the marine environment (anthropogenic and climate change induced pressure), and of the environmental characteristics of the region including its physical and biochemical oceanography.

Please acknowledge and refer to the original sources and citations of each of the datasets (provided below).

This map, Biodiversity Features, comprises four types of data: (a) Distribution of existing Marine Protected Areas, (b) seven layers of biodiversity features, (d) two types of threat, and (e) 16 environmental variables.

The original citations of data sources

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Table S1. Coral Triangle datasets specifications.

Data layer	Feature	Type, Spatial Resolution, Class	Descriptions	References
1	*2*	*3*	*4*	*5*
Base Layers				
a. Coral Triangle boundary	Generated from the Coral Triangle Initiative Implementation boundary	Polygon	The boundary covers the full exclusive economic zones (EEZs) of Indonesia, Malaysia, Papua New Guinea, the Philippines, Solomon Islands, and Timor-Leste, and includes the EEZs of two additional nations: Brunei Darussalam and Singapore.	VLIZ, (2014)
b. Country boundary	Internal boundary of Coral Triangle countries	Polyline	The EEZ and internal boundaries are indicative only, and a dispute over boundaries exists.	VLIZ, (2014)
c. Marine protected areas (MPA) coverage	Coverage of 678 units of MPA	Polygon	The layers' attribute table provides detailed information following its native sources (WDPA, CTAtlas) (e.g., information of Name, Local Name, Designation Type, IUCN Category, coverage	IUCN & UNEP-WCMC (2016); Cros *et al.* (2014);

Table S1. continued

1	*2*	*3*	*4*	*5*
			etc.) (IUCN & UNEP-WCMC,2016; Cros *et al.*,2014) with amendment and adjustment from local sources (Indonesian database). To allow simple indexing, a new CT MPAs ID format (MPA_ID) is introduced. The new ID consists of 10 digits: "A BC DEFG HIJ"	MoF-MoMAF (2010); MoMAF (2016).
Biodiversity Features				
a. Biogenic Habitat	Spatial distribution of coral reef, seagrass and mangroves.	Grid square cells; 5 km; 3 classes	Calculated based on the number of biogenic habitat present in each cell. Cell values ranged from 1 – 3.	IMaRS-USF. & IRD., (2005); UNEP-WCMC et al., (2010); Giri et al., (2011a), (2011b); UNEP-WCMC & Short, (2005)
b. Species richness - Ranges	A modeled geographic distribution of 10,672 species ranges.	Grid square cells; 50 km; 10 classes	Calculated based on the number of predicted species in each cell. The number of predicted species per cell ranged from 0 to 5,509.	Kaschner *et al*. (2016)
c. Species richness - Occurrence	The occurrence records of 19,251 species.	Grid square cells; 50 km; 10 classes	Based on the index of expected species richness of ES_{50} (estimated species in random 50 samples).	OBIS, (2015)
d. Species of conservation concern	The occurrence records of 834 species of conservation concern (Bony fish, anthozoans, elasmobranchs, mammals, and molluscs).	Grid square cells; 50 km; 10 classes	Based on the index of expected species richness of ES_{35} (estimated species in random 50 samples).	OBIS, (2015); Froese & Pauly, (2016); IUCN (2015); UNEP-WCMC (2015)
e. Species of restricted-range	The distribution of 373 restricted-range reef fish species.	Grid square cells; 5 km; 10 classes	Calculated based on the number of species present in each cell. Cell values ranged from 1 – 101.	Allen, (2008); Allen & Erdmann, (2012)
f. Important areas for sea turtle	Nesting sites and migratory route of 6 species (2,055 records).	Grid square cells; 5 km; 3 classes	The richness calculated based on the number of sea turtle species present in each cell (*i.e.,* 1, 2, 3).	MoF-MoMAF, (2010); OBIS, (2015)

Table S1. continued

1	*2*	*3*	*4*	*5*
g. Habitat rugosity	A Vector Ruggedness Measure (VRM) of benthic terrain, generated from bathymetric data.	Grid square cells; 50 km; 10 classes	The VRM index ranged from 0.1 (areas with low terrain variations to 0.9 (areas with high terrain variations).	Basher *et al.*, (2014); Wright *et al*., (2012)
h. Anthropogenic Pressure (AP)	Spatial distribution of AP on marine environments.	Grid square cells; 5 km; 10 classes	The cumulative impact of 19 different types of anthropogenic stressors. The AP value ranged from 0 – 15.4, indicating areas from low to high human-induced pressure.	Halpern *et al.*, (2008); Halpern *et al.*, (2015)
i. Climate Change Pressure	Spatial distribution of sea surface thermal stress level (the average of Degree Heating Weeks (DHW) from 2006 to 2099.	Grid square cells; 5 km; 10 classes	The projected thermal stress index ranged from 5.6 – 20.2, indicating areas from low to high vulnerability to climate change.	Van Hooidonk *et al.,* (2016)
j. Environmental Variables	Spatial distribution of environmental variables (physical, biochemical and nutrients).	Point; 50 km; 10 classes	Composite point features of 16 environmental variables, i.e., depth, slope, land distance, temperature, surface current, salinity, wind speed, tide, primary productivity, photosynthetically active radiation (PAR), chlorophyll-a, pH, dissolved oxygen, nitrate, silicate, and calcite.	Basher *et al.*, (2014).
Areas of Importance for Biodiversity Conservation				
a. Regional biodiversity hotspots	Clusters of areas of biodiversity importance.	Grid square cells; 55 km; 3 classes of hotspots (high, medium and low) and 1 class not significant	Developed based on the multi-criteria analysis to five ecological criteria (sensitive habitat, species richness, the presence of species of conservation concern, the occurrence of restricted-range species, areas of importance for particular life history stages). Analyzed based on the spatial patterns of data using the hotspots analysis tool in ArcGIS. The analysis clustered the cells from hotspot (high score cells) to coldspots (low score cells).	Asaad *et al.,* (2018a).

Table S1. continued

1	*2*	*3*	*4*	*5*
b. Sites of biodiversity importance	Distribution of sites of areas of biodiversity importance.	Grid square cells; 55 km; 5 classes (high, medium-high, medium, medium-low and low)	Developed based on the similar ecological criteria to those used in the biodiversity hotspots region analysis. While the hotspots analysis identified clustered areas of biodiversity importance ,The site-based analysis identifies specific sites of highest biodiversity importance by analyzing the biodiversity score of each cell. The higher the score, the higher their biodiversity importance.	Asaad *et al.,* (2018a).
a. Sites of biodiversity importance	Distribution of sites of areas of biodiversity importance.	Grid square cells; 55 km; 5 classes (high, medium-high, medium, medium-low and low)	Developed based on the similar ecological criteria to those used in the biodiversity hotspots region analysis. While the hotspots analysis identified clustered areas of biodiversity importance ,The site-based analysis identifies specific sites of highest biodiversity importance by analyzing the biodiversity score of each cell. The higher the score, the higher their biodiversity importance.	Asaad *et al.,* (2018a).
Marine Protected Area (MPA) Network Expansion				
a. Regional priority areas	Spatial distribution of regional priority areas with three expansion scenario layers: 10%, 20% and 30%.	Grid square cells; 0.5 km	Prioritization analyses were performed using *Zonation* tools to analyze the proportions of the CT region placed into an MPA network (*e.g.,* expansion of the MPA network from existing coverage to 10%, 20% and 30 % of the Economic Exclusive Zone (EEZ) area). The prioritization scenarios were based on seven sets of biodiversity features (biogenic habitat, habitat rugosity, species richness, distribution of threatened and endemic species, areas important for sea turtle); two types of threat (anthropogenic and climate change induced pressure); and the coverage of the existing MPA network. Regional analyses were performed for the full CT EEZ region.	Asaad *et al.,* (2018a).

Table S1. continued

1	2	3	4	5
b. National Priority Areas	Spatial distribution of national priority areas with six layers of scenarios representing national MPA network expansion for Indonesia, Malaysia, the Philippines, Papua New Guinea, Solomon Islands and Timor Leste.	Grid square cells; 0.5 km	Developed based on the same approach as the regional priority areas. National analyses were performed individually on each CT country national EEZ. Each layer consisted of 3 scenarios of MPA expansion (10%, 20%, 30%)	Asaad *et al.,* (2018b).

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121 **1.3. Digital Map of the Areas of Biodiversity Importance in the Coral Triangle**
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123 The digital map of areas of biodiversity importance in the Coral Triangle is comprised of: (1) Regional
124 biodiversity hotspots, (2) Sites of biodiversity importance.

125 This dataset is comprised of two layers of areas of biodiversity importance. Each layer was developed
126 based on a multi-criteria analysis of five ecological criteria: (1) fragile and sensitive habitat (the coverage
127 of biogenic habitats: coral reefs, seagrass and mangrove); (2) species richness (modeled geographic
128 distributions of 10,672 species ranges and occurrence records of 19,251 species); (3) the presence of
129 species of conservation concern (distributions of 834 species of special conservation concern); (4) the
130 occurrence of restricted-range species (distributions of 373 restricted-range reef fish species); and (6)
131 areas of importance for particular life history stages (distribution of six species of sea turtle).

132 The datasets were clipped to the CT region using a grid approach of half-degree cells (0.5°), where each
133 cell covered an area of ~ 55 x 55 km. All of the datasets obtained from each criterion were superimposed
134 to produce an integrated dataset. The areas of biodiversity importance were analyzed based on the
135 biodiversity score of each cell. The score of each criterion was calculated based on the total number of
136 habitat, species or species index that fell within each cell.

137 The map comprises:

138 a) The regional biodiversity hotspots analyzed using ESRI's hotspots analysis tools ESRI ArcGIS
139 (ESRI, 2016b; Getis & Ord, 1992; Ord & Getis, 1995). The statistically significant Z scores (GI*
140 statistics) were analyzed by comparing the local sum of a cell's score and its neighbors
141 proportionally to the sum of all cells' scores. The hotspots analysis clustered the area into three
142 classes of hotspots (99%, 95% and, 90% confidence level), and one class of non-statistically
143 significant clusters.
144 b) The sites of biodiversity importance that identified areas of biodiversity importance by analyzing
145 the biodiversity score of each cell. The higher the score, the higher their biodiversity importance.
146 The cells were ranked into five equal interval classes, from high to low biodiversity importance.
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1.4. Digital Map of the Priority Areas for MPA Network Expansion

The digital map of priority areas for marine protected area (MPA) network expansion in the Coral Triangle region is comprised of: (1) Regional priority areas, (2) National priority areas.

Spatial distributions of priority areas for marine protected area network expansion are illustrated for the Coral Triangle. These datasets were developed using the conservation prioritization tool of *Zonation*, by analyzing the proportions of the CT region's area that is within the existing CT MPA network and then prioritizing areas for MPA network expansion (*e.g.,* expansion of the MPA network from existing coverage to 10%, 20% and 30 % of the Economic Exclusive Zone (EEZ) area).

These datasets comprise two sets of maps: (1) Regional priority areas (performed for the full CT EEZ region) and (2) National priority areas (performed individually on each of the CT country national EEZs).

All analyses were performed using sets of raster grids, with a spatial resolution of 500 m. The prioritization analyses were based on seven different sets of biodiversity features: biogenic habitat, habitat rugosity, species richness, distribution of threatened and endemic species, areas important for sea turtles, two types of threat (anthropogenic and climate change induced pressure), and the coverage of the existing MPA network.