Data Quality Control for The Coral Triangle Atlas

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Abstract

The Coral Triangle Atlas (CT Atlas) was developed to provide scientists and managers the best available data on marine resources in the Coral Triangle. Endorsed as an official supporting tool to the Coral Triangle Initiative by the government of the six countries defining the Coral Triangle, the CT Atlas provides the most accurate information possible to track the success of the conservation efforts of the initiative. Focusing on marine protected areas and habitats, the CT Atlas tested a process to assess the quality, reliability and accuracy of different data layers. Several main issues were highlighted by the quality control process: errors in reputable datasets, outdated and missing data, metadata gaps, lack of user instructions to interpret layers and different resolutions. These challenges need to be addressed before the data is distributed or used for analysis, in particular at the regional level and may require more time and funding than previously estimated.

Introduction

The Coral Triangle defines an area that captures the global center of marine diversity (Allen, 2007; Hoeksema, 2007, Veron *et al*, 2009), and a global priority for conservation (Hughes *et al*,. 2002; Roberts *et al.*, 2002; Wallace *et al.*, 2001). It comprises six countries (CT6): the Philippines, Malaysia, Indonesia, Papua New Guinea, Timor Leste and Solomon Islands. It has been a major focus for coral reef conservation efforts since September 2007 when President Yudhoyono of Indonesia first proposed a Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security (CTI) uniting the six governments in a multilateral partnership to conserve the extraordinary marine life of the Coral Triangle.

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With the support of international and local NGOs as well as government agencies, the Coral Triangle Atlas has been developed as a partnership, centralizing and compiling information spread over the six countries. The aim of the CT Atlas is to provide the best available information for scientists and managers to better conserve and track marine resources. Endorsed by the CT6 as an official tool to support their measures and evaluation team, the CT Atlas has given priority to layers that inform the CTI's indicators of success, in particular, the boundaries and status of marine protected areas (MPAs), coral reef area and other critical habitats and threats.

The data is used for national and regional analysis to track progress against CTI objectives. This requires accurate, reliable data that can be used with confidence at the highest political level. To achieve this we carefully reviewed data documentation and analyzed dataset for integrity and errors.

The mechanism to validate these layers and to successfully provide accurate data to the countries is described in this report, demonstrating the value and the challenge of acquiring quality regional data.

Methodology

We selected layers representing key marine habitats: coral reefs, mangroves, seagrass, marine protected areas and other related biodiversity layers (e.g. turtle nesting).

We carried out several types of quality control:

1. In reviewing metadata we focused on:
    a. The source of the data: e.g. does it exist, is it up to date, and is it trustworthy?
    b. The date of creation: e.g. is there a date, how recent is the information, was it updated?
    c. The method of data collection: e.g. do we have a description of collection of the data, which satellite was used, is it expert knowledge, volunteer monitoring, expert monitoring?

   The reviewer made an informed decision as to the quality and trustworthiness of the layer and if it should stay in the database or be removed.

2. A comparison of several sources with two objectives: to identify any discrepancies between sources, and to create a process to select the better of the two sources.

3. A quality assessment of the data: Is the data complete? Is it representative of the information? Is the scale of the data appropriate? Does it cover the full extent of the Coral Triangle?

The results were discussed among the team and a final decision was made as to which layers to use, which were obsolete and which were currently inappropriate for the CT Atlas. We recognize that incomplete data now, may lead to higher quality in the future. Therefore we maintain a separate listing of such data

Results

Several types of issues came out from the quality control: incomplete information to make a good assessment of data quality, errors in reputable datasets, out of date data, differences in methodologies and incomplete datasets.

   1. Metadata

Many of the biodiversity data layers were missing detailed metadata, including source of information, date, and method of collection or a description of the data. Data on turtles, cetaceans and other endangered species was discarded or removed from the database as a consequence.

For example, the layer "Critical habitat sites of green, leatherback and hawksbill turtles in the Coral Triangle" (Fig. 1) was created from the Ministry of Forestry & WWF Indonesia data from 2009. However, there was no information on how the data was collected across the Coral Triangle, the dates of

collection; the value of a point data. The metadata needs to be completed before this layer can be published with confidence in the quality of the information shared.
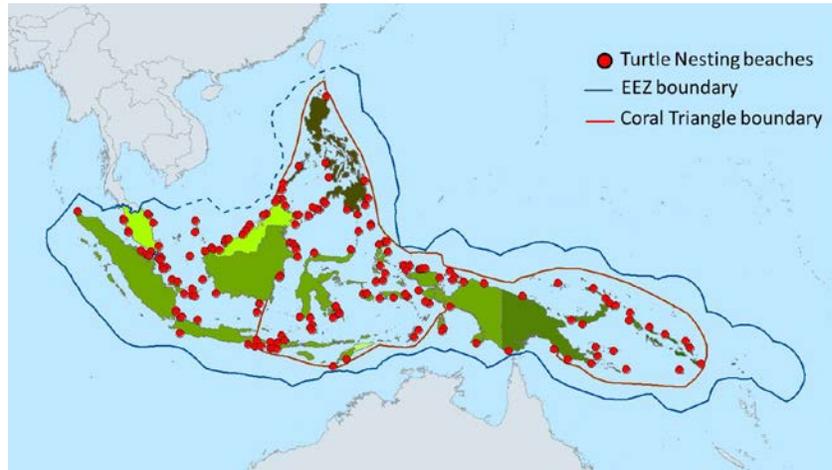

Fig 1. Critical turtle habitat map compiled by the Ministry of Forestry and WWF Indonesia. While this maps looks nice, the quality of the information provided is uncertain.

2. Multiple layers

Coral Reefs

Four sources of data for coral reefs were compared: United Nation Environment Program and World Conservation Monitoring Center (UNEP–WCMC) Global Distribution of Coral Reefs (2010), World Resource Institute (WRI) from the 2008 Reefs@Risk Revisited report, Global Coral Reef Monitoring Network (GCRMN), Status of coral reefs of the world by Wilkinson (2008) and UNEP-WCMC World Atlas of Coral Reefs by Spalding et al (2001).

The analysis of the total area of coral reefs within each country of the Coral Triangle revealed a discrepancy between the two most recent data sources (Table 1). The area from WRI was approximately twice the area from UNEP-WCMC.

	Indonesia	Malaysia	PNG	Philippines	Solomon Islands	Timor-Leste
UNEP - WCMC (2010) **Global Distribution of Coral Reefs**	19,805	1,687	7,126	11,852	2,802	35
WRI (2011) **Reefs@Risk Revisited**	39,538	2,935	14,535	22,484	6,743	146
Wilkinson, C. (2008) **Status of coral reefs of the world.** GCRMN.	50,875	4,006	NA	25,819	5,750	NA
Spalding M.D. et al. (2001) **World Atlas of Coral Reefs**. UNEP-WCMC.	51,020	3,600	13,840	25,060	5,750	NA

Table 1. Comparison of the area of coral reef (in km^2) calculated by several sources for the six countries of the Coral Triangle.

A closer look into the two datasets helps to understand the difference in area of coral reef cover (Table 2). Both data sets have similar sources: the UNEP-WCMC data consists of vector spatial data, 85% of which was obtained from the Millennium Coral Reef Mapping Project (mapped at 30m resolution using Landsat images), and from various other sources. The WRI data also relies mainly on the Millennium Coral Reef Mapping Project and completes it with other various sources as well. However, to standardize the data for the Reefs at Risk Revisited project, WRI converted all their data to a 500m grid in raster format. This procedure almost doubles the total area of coral cover, as original small patches of coral reef are converted to grid cells of a $0.25km^2$ in size. The reason for converting the reef data to 500m grids is to represent the reef slopes and deeper reefs typically undetectable from satellite remote sensing.

	UNEP-WCMC (2010)	WRI (2011)
Sources	▪ Millennium Coral Reefs (Unvalidated) ▪ Millennium Coral Reefs (Validated) ▪ Other sources	▪ Millennium Coral Reefs (Unvalidated) ▪ Millennium Coral Reefs (Validated) ▪ UNEP-WCMC. *Coral Reef Map*. 2002. ▪ Other Sources
Spatial Resolution	▪ 30m resolution ▪ Scales for data from other sources range from 10,000 to 8,000,000	▪ 500m resolution ▪ Scales for data from other sources range from 60,000 to 1,000,000

Table 2. Summary of sources of data for the UNEP-WCMC (2010) layer and WRI (2011) layer.

Mangroves

Four sources of data for mangroves were compared: Spalding et al. (2010) World Atlas of Mangroves, Giri et al. (2011) Status and Distribution of Mangrove Forests of the World using Earth Observation Satellite data, UNEP-WCMC (1997) The Global Distribution of Mangroves and FAO (2007) The World's Mangroves 1980-2005.

	Indonesia	Malaysia	PNG	Philippines	Solomon Islands	Timor-Leste
Spalding et al. (2010) **World Atlas of Mangroves**	31,894	7,097	4,265	2,565	603	-NA
Giri et al. (2011) **Status and Distribution of Mangrove Forests of the World using Earth Observation Satellite data.**	31,130	5,054	4,801	2,631	-NA	-NA
UNEP-WCMC (1997) **The Global Distribution of Mangroves**	44,995	6,395	5,374	1,601	No Mangroves	No Mangroves
FAO (2007) **The World's Mangroves** 1980-2005	29,000	5,650	3,800	2,400	415	18

Table 3. Comparison of the area of mangroves (in km^2) calculated by several sources for the six countries of the Coral Triangle.

The analysis of the total area of mangroves within each country of the Coral Triangle revealed a discrepancy among all of the data and some specific differences between the two most recent references (Table 2).

A closer look at the GIS layers of the World Atlas of Mangroves showed that most of Malaysia's mangrove had two copies of nearly the same polygons which were overlaid and most likely caused the error in calculation. The small differences between the other five areas are due to the use of different sources, Spalding et al. (2010) using various sources while Giri et al. (2011) basing their data on Landsat 30m resolution imagery.

3. Digitization error

Coral Reefs

	Indonesia	Malaysia	PNG	PHIL	Solomon Isl.	Timor-l'Este
UNEP-WDPA Downloaded in 2009						
	19,805	1,687	7,126	11,852	2,802	35
UNEP-WDPA Downloaded in 2010						
	35,356	3,174	7,130	23,606	2,803	146

Table 4. Comparison of UNEP-WDPA coral reef data downloaded from UNEP Ocean Viewer (http://data.unep-wcmc.org/) in 2009 and in 2010

The most updated layer (2010) of coral reef from UNEP- WCMC (WDPA) proved to have a series of overlaid copies of the same polygons, doubling the area of coral reef in each country.
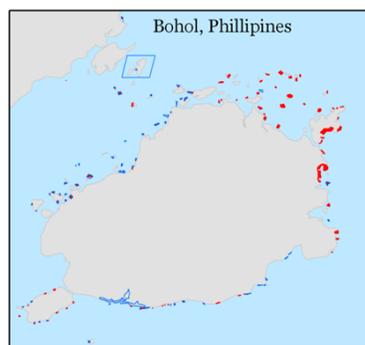
4. Outdated and misclassified data

MPAs

Fig 2. Comparison of MPAs from WDPA (in blue) and CT Atlas compilation MPAs (red). Some of the MPAs in the WDPA do not exist anymore.

WDPA data was compared to the compilation of MPAs by the Coral Triangle team who went directly to the source, working directly with government agencies to create and update their MPA database. WDPA seemed to have many MPAs which either never officially existed, either as an MPA or as a LMMA or didn't exist anymore.
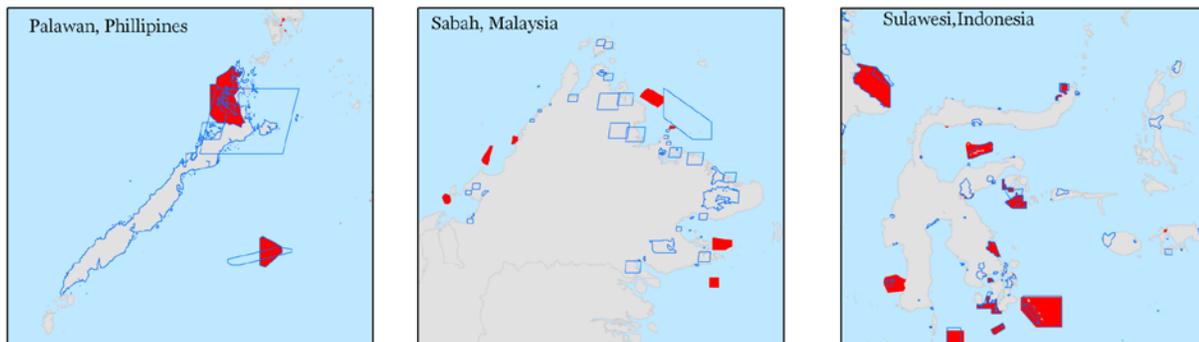
Fig 3. Comparison of MPAs from WDPA (in blue) and CT Atlas compilation MPAs (red). Many WDPA MPAs are mostly terrestrial, which marine components such as a beach.

By further comparison between WDPA MPAs and CT Atlas MPAs, it was clear that some of the discrepancy in area came from the different definitions of MPAs. WDPA MPAs are Protected Areas (Pas) that have a marine component. This results in classifying PAs that are mostly terrestrial but with a beach or mangrove as an MPA while the intent of the protection is only terrestrial. In Malaysia, entire islands are considered MPAs when only the waters around the island are protected.

Other missing information

For a high quality MPA layer, further information would be needed to complete the current layer.
This includes:
- o Zoning information. For example only 23.2% of the WDPA for the Coral Triangle countries has information on "No Take" zones.
- o Management effectiveness. For example only 54% of MPAs in Reefs@Risk revisited has this information.
- o Documented Locally Managed Areas

5. **Different resolutions**

Some of the earlier analysis done for the Coral Triangle was using ecoregions as management units and bounded by the scientific Coral Triangle scientific boundary (Veron *et al*. 2009). With the development of the Coral Triangle Initiative and for political reasons, most of the recent analysis is carried out by country. It is difficult to reconcile one resolution with the other, making the data less likely to be used by managers.

Discussion

Five main issues were highlighted by the quality control process: errors in reputable datasets, outdated and missing data, metadata gaps, lack of user instructions to interpret layers and different resolutions.

The data reviewed in this report represent the habitat features that are being used by the CT6 to track indicators of success under the CTI, making these layers even more critical to evaluate. The proliferation of errors in one data set may be compounded when used with other imperfect data sets. For example, one of the most common issues the CT Atlas has come across is the calculation of coral reefs protected by MPAs. If the countries use an MPA layer that overestimates the area of MPAs in the country (WDPA)

with a coral reef layer that is represented with a 500m grid (Reefs@Risk Revisited), the area of coral reef protected by MPAs will be greatly overestimated. In Table 1, we see that the coral reef area from Reefs@Risk Revisited is the double of what is calculated using UNEP-WCMC data. This may result in a government coming to the erroneous conclusion that they have reached their goal of coral reef protection via MPA. The consequences could be a decrease in the effort to create new MPAs, or donors to donate new funding.

Compiling several data layers is useful, and often necessary, but is hampered when metadata records are incomplete. The example given in this report (Fig. 1) of the "Critical Turtle Habitat" is a typical situation where although the data looks good presented in a single map, the actual quality of the data can't be assessed. The consequence is that the public, stakeholders, managers, and donors get the impression that the data exist and that it can be used for spatial planning or resource management. Whereas the features represented on a map may in fact be from a low quality source, out of date, or inconsistent.

Some of the data layers in the CT Atlas are of very high quality, however they may lack instructions for users to fully understand under which circumstances the data can be used and what are the limitations for interpretation. One example is the Reef@Risk Revisited, which transformed their data to 500m grid to be able to perform threat analysis. Area of features should not be extracted from these layers since they will be grossly overestimated. Another example, not discussed in this report is the oceanographic data. These complex data sets often require assistance or guidance from data providers to ensure the data are properly interpreted. Users should rely on experts to interpret these data and provide the correct information. The CT Atlas provides links to appropriate resources for using these data.

Managing at the regional scale requires data at the same scale. For the success of the CTI, it is key to be able to provide data that is cohesive across all six countries. This is challenging because each country often has their own data layer created with their own method which may result in very different measures. This is the case for example with the habitats layers, seagrass, mangroves and coral reefs. This is why it is critical not only to provide the six countries of the Coral Triangle with data that is homogeneous over the region but also to be able to demonstrate that it is the best data available. Quality control of this data will help build trust within countries to use the data but also to contribute to it to keep it update, as is the case with the MPA data which cannot be controlled without the involvement of government agencies.

An unfortunate issue with using trustworthy data sources is that end users are less likely to check for errors. In many cases layers are blindly used in analysis without prior checking. Quality checks at the provider level are critical to minimize these types of errors. This first round of quality control has proved that this is a necessary step and one that is often overlooked by data providers. Reasons for this are that it is a time consuming and therefore costly process. Good data is the base of any analysis, yet the quality of base layers is often overlooked. Users often sum it up by "it's the best and only data available". Additionally, funding is generally scarce in this area, making it even more difficult to justify spending the time on the process. This preliminary analysis has clearly show the impact that bad quality or wrongly used data can have on measure of success, and in the end conservation action of an entire region.

Conclusion

The results presented here exemplify the impact of inconsistent sources of information could have at a local and regional scale, and how this could hinder management decisions and conservation goals.

Having a consistent process to compare several sources of data allows discrepancies to be detected and underlines errors or, differences in methodology, as seen in the examples here. Work still has to be carried out to help governments understand which data is reliable.
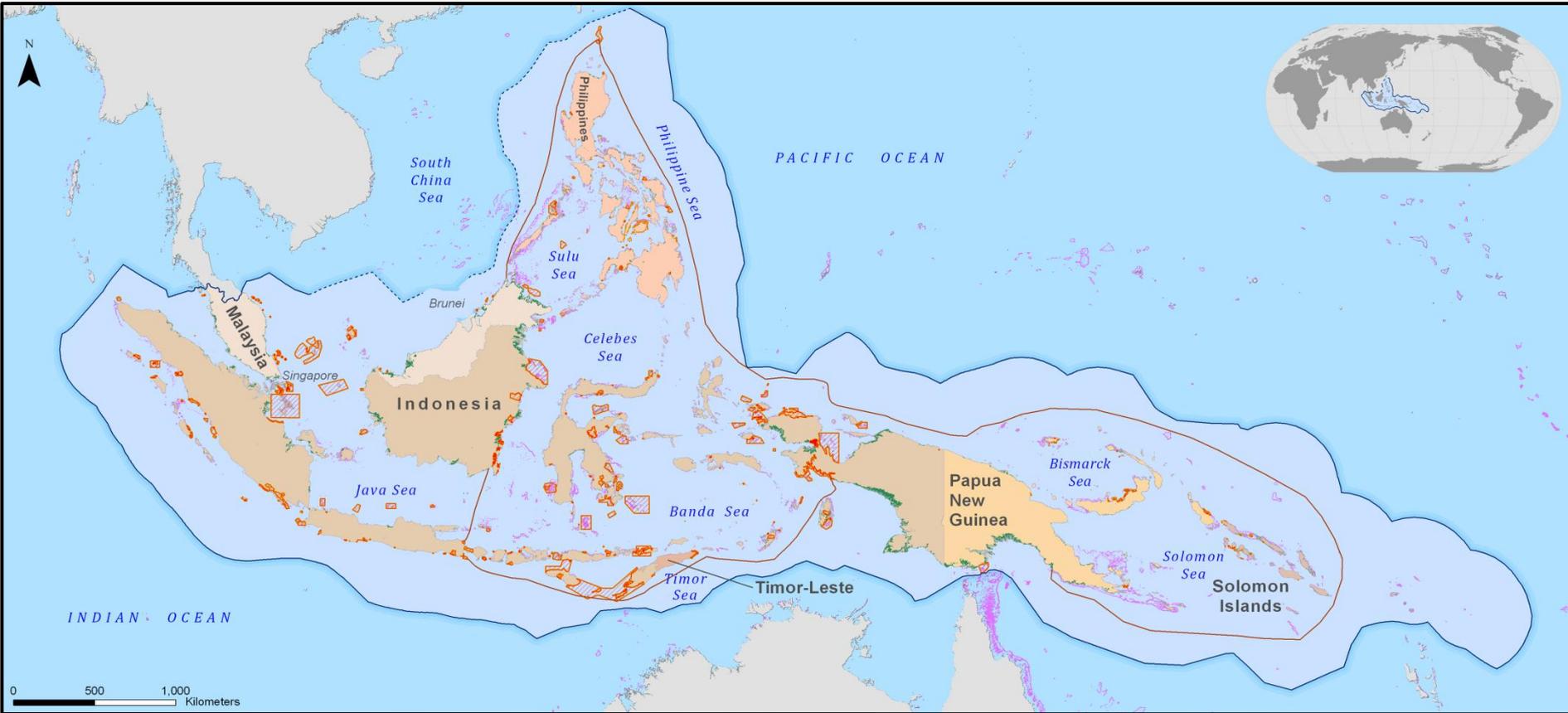
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UNEP World Conservation Monitoring Centre (1997) Global distribution of Mangroves (http://data.unep-wcmc.org/datasets)

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Acknowledgement:

Marine Protected Areas (MPAs) in Coral Triangle

Map labels:
PACIFIC OCEAN
South China Sea
Philippines
Philippine Sea
Sulu Sea
Brunei
Celebes Sea
Malaysia
Singapore
Indonesia
Java Sea
Banda Sea
Timor Sea
Timor-Leste
INDIAN OCEAN
Bismarck Sea
Papua New Guinea
Solomon Sea
Solomon Islands

Scale: 0 — 500 — 1,000 Kilometers

Legend

- MPAs
- Coral reefs
- Mangroves

- ～ Coral Triangle scientific boundary (Veron *et al*. 2009)
- ～ Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security (CTI-CFF) implementation area
- ······· Dashed line represents disputed EEZ boundary

DATA SOURCES:
EEZ boundaries: Veridian (2002) Global Maritime Boundaries Database.
Coral reefs: WRI (2011) *Reefs at Risk Revisited*.
Mangroves: UNEP-WCMC (2010) *Mangroves of the World 2010*.
       Preliminary global dataset provided to ReefBase.
MPAs: Compiled from various sources including the World Database of Protected Areas (WDPA), TNC, ReefBase and national agencies.

NOTE:
1. Singapore and Brunei are not members of the CTI-CFF;
2. This boundary is based on the Exclusive Economic Zones (EEZ) of the CTI countries. EEZ internal boundaries are not shown;
3. Disputed boundaries exist in this geography;
4. Boundaries are only for illustration and are not legally binding.

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CTSP
Coral Triangle Support Partnership
WWF — The Nature Conservancy — CONSERVATION INTERNATIONAL

CORAL TRIANGLE ATLAS

WorldFish CENTER

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Number of **MPAs** (known boundaries)*		1 (1)
Total MPAs area (km²) for known boundaries		586
MPAs in EEZ (%)		1.5
Coral Reef area (km²)**		35
Reef area in MPAs (km²)		11
Reefs in MPAs (%)		30
Mangrove area (km²)***		No mangrove
Mangrove area in MPAs (km²)		-
Mangrove in MPAs (%)		-

❑ **MPA Management Authority:**
- Department of Protected Areas & National Parks, Ministry of Agriculture and Fisheries, Timor-Leste

❑ Only has **one MPA** declared – Nino Konis Santana National Park. The total area of national park is 1,257 km², consists of 586 km² of the marine area.

❑ **Coral Reef:**
- Number of coral species (Veron *et al.*, 2009): 514
- Coral destruction mainly due to destructive fishing.

❑ **Mangrove:**
- Number of mangrove species (Spalding *et al.*, 2010): No mangrove reported
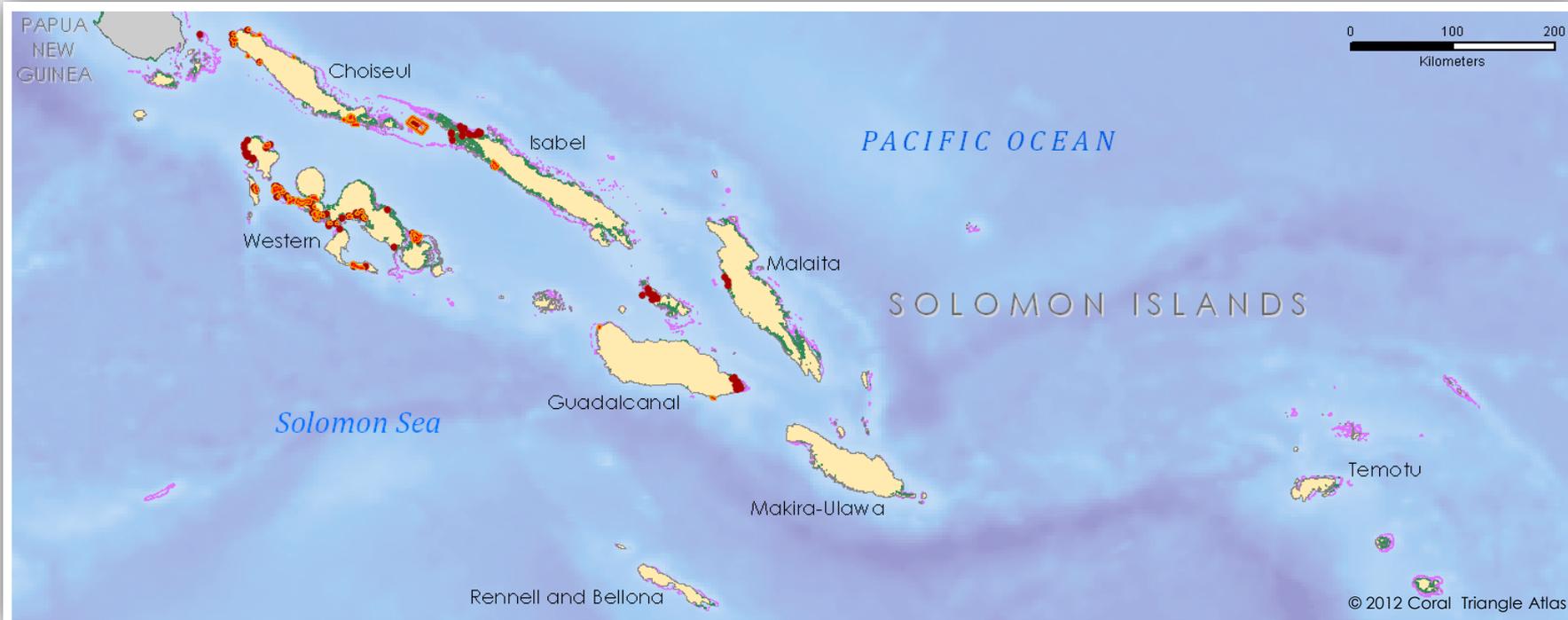
*Compiled from various sources by CT Atlas team up to July 2012;
**UNEP-WCMC (2010) Global Distribution of Coral Reefs. Download from UNEP-WCMC's Ocean Data Viewer (http://data.unep-wcmc.org/datasets/13) and further correcting the topology error by CT Atlas team (2012);
***UNEP-WCMC (2010) Mangroves of the World 2010. Preliminary global dataset provided to ReefBase.

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● 🔲	Number of **MPAs** (known boundaries)*	118 (50)
	Total MPAs area (km²) for known boundaries	402
	MPAs in EEZ (%)	0.03
🌸	**Coral Reef** area (km²)**	2,802
	Reef area in MPAs (km²)	52
	Reefs in MPAs (%)	2
🍀	**Mangrove** area (km²)***	614
	Mangrove area in MPAs (km²)	6
	Mangrove in MPAs (%)	1

❑ **MPA Management Authority:**
- Locally Managed Marine Areas (LMMA) network

❑ **Coral Reef:**
- Number of coral species (Veron *et al.*, 2009): 207
- Major threat to coral reefs is overfishing (GCRMN, 2004)

❑ **Mangrove:**
- Number of mangrove species (Spalding *et al.*, 2010): 22
- Mangrove is legally protected under the resources and timber regulation act but mangrove degradation still continues from legal and illegal logging (Spalding *et al.*, 2010)

*Compiled from various sources by CT Atlas team up to July 2012;
**UNEP-WCMC (2010) Global Distribution of Coral Reefs. Download from UNEP-WCMC's Ocean Data Viewer (http://data.unep-wcmc.org/datasets/13) and further correcting the topology error by CT Atlas team (2012);
***UNEP-WCMC (2010) Mangroves of the World 2010. Preliminary global dataset provided to ReefBase.

● ▨	Number of **MPAs** (known boundaries)*	1,557 (344)
	Total MPAs area (km^2) for known boundaries	10,724
	MPAs in EEZ (%)	0.6
❀	**Coral Reef** area (km^2)**	11,852
	Reef area in MPAs (km^2)	356
	Reefs in MPAs (%)	3
❀	**Mangrove** area (km^2)***	2,562
	Mangrove area in MPAs (km^2)	88
	Mangrove in MPAs (%)	3

*Compiled from various sources by CT Atlas team up to July 2012;
**UNEP-WCMC (2010) Global Distribution of Coral Reefs. Download from UNEP-WCMC's Ocean Data Viewer (http://data.unep-wcmc.org/datasets/13) and further correcting the topology error by CT Atlas team (2012);
***UNEP-WCMC (2010) Mangroves of the World 2010. Preliminary global dataset provided to ReefBase.

❑ **MPA Management Authority:**
- National Integrated Protected Areas System (NIPAS) Act of 1992
- 29 national MPAs have been created in addition to more than 1000 locally declared MPAs
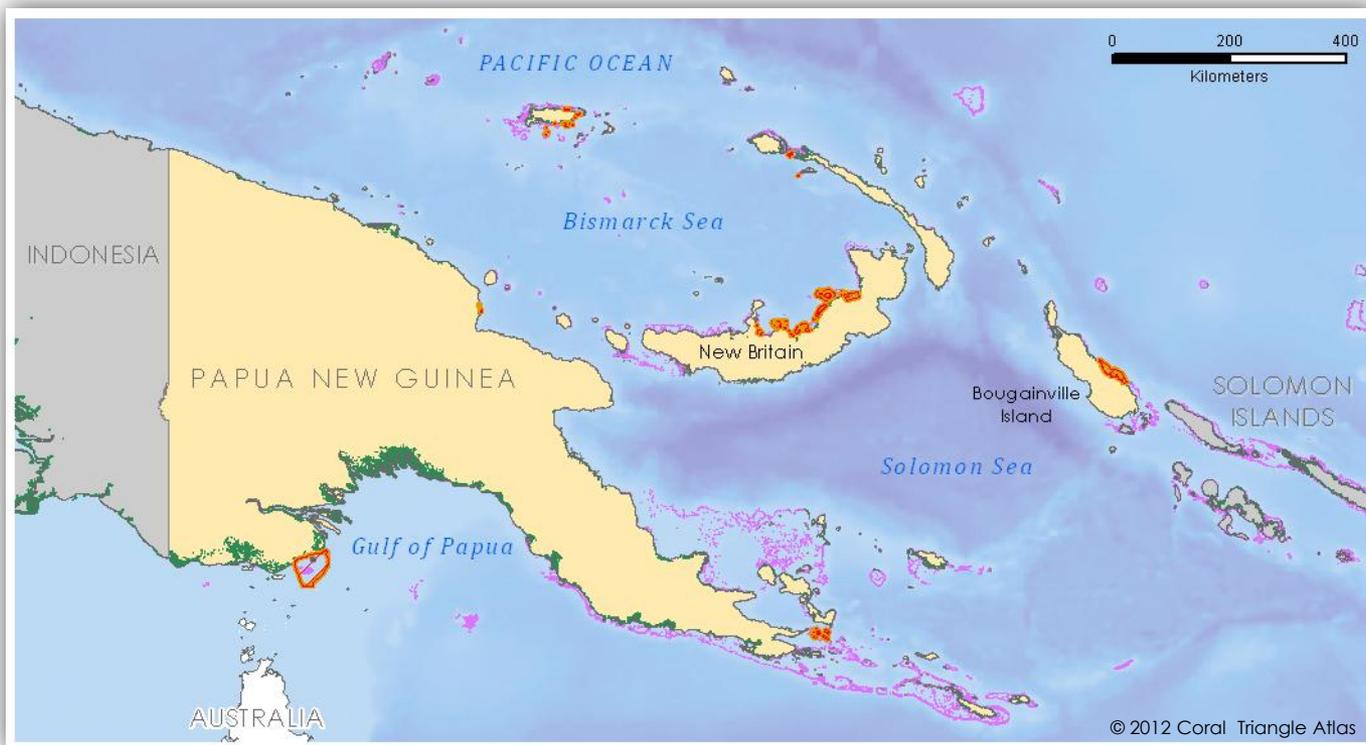
❑ **Coral Reef:**
- Number of coral species (Veron *et al.*, 2009): 533
- Current data suggests that the reefs are experiencing 3-5% coral cover reduction. In the 1980s, 33% of reefs were categorized as poor; that number increased to 40% two decades later (GCRMN, 2004)

❑ **Mangrove:**
- Number of mangrove species: 30 (Spalding *et al.*, 2010)
- Mangrove decline primarily due to aquaculture conversion
- Many mangroves are protected within small reserves; some are contained in large protected seascapes

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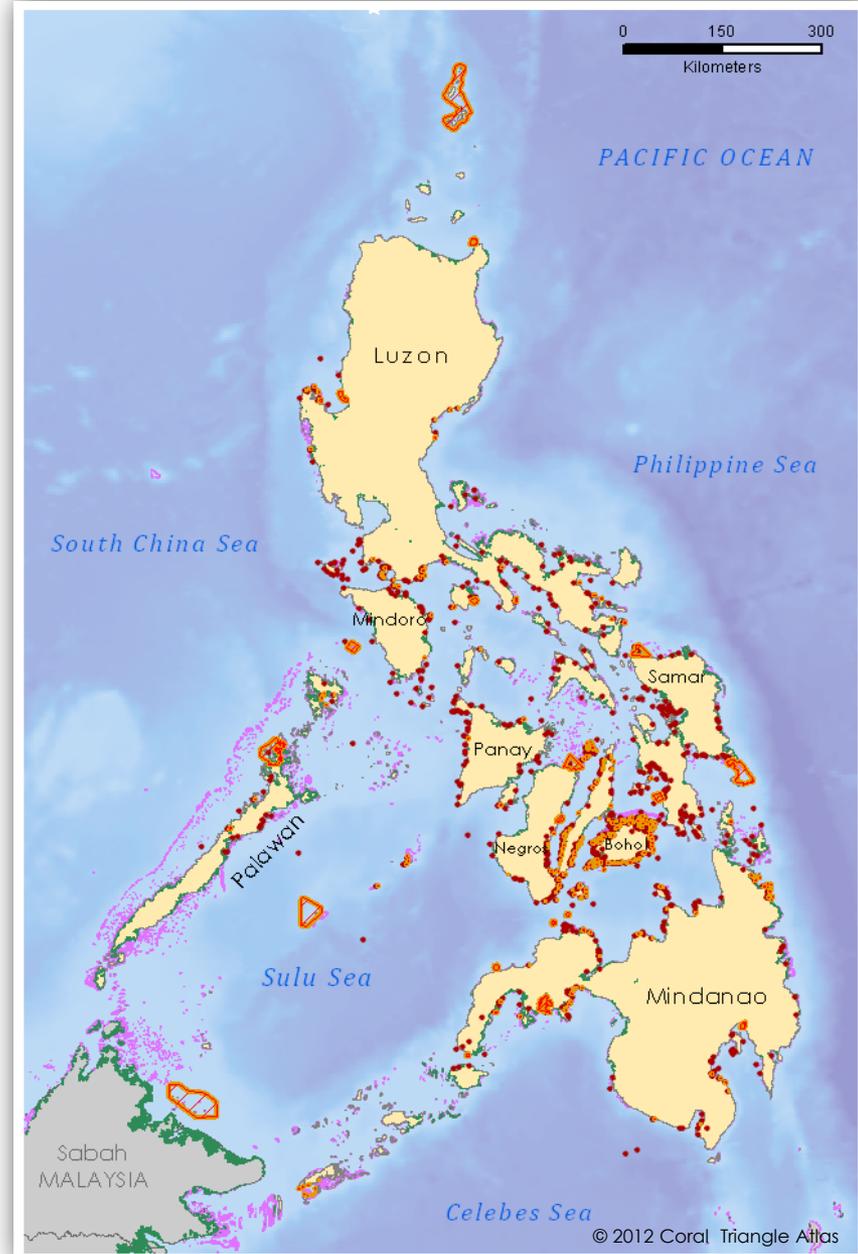
Number of **MPAs** (known boundaries)*		63 (39)
Total MPAs area (km²) * for known boundaries		4,550
MPAs in EEZ (%)		0.2
Coral Reef area (km²)**		7,126
Reef area in MPAs (km²)		300
Reefs in MPAs (%)		4
Mangrove area (km²)***		4,159
Mangrove area in MPAs (km²)		35
Mangrove in MPAs (%)		1

❑ **MPA Management Authority:**
- (Locally Managed Marine Areas) LMMA network

❑ **Coral Reef:**
- Number of coral species (Veron *et al.*, 2009): 514
- Information on PNG reefs is limited with little research, monitoring and management capacity (GCRMN, 2008)
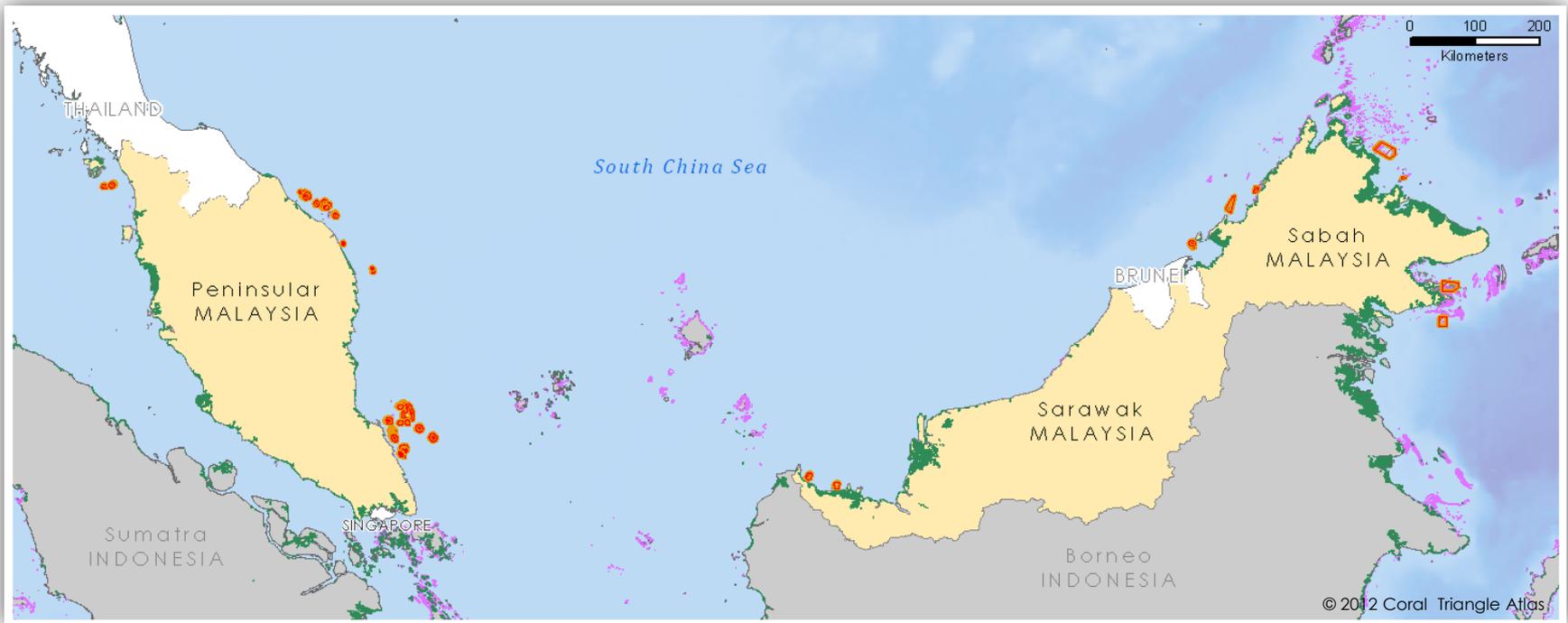
❑ **Mangrove:**
- Number of mangrove species (Spalding *et al.*, 2010): 44
- Greatest threat to mangroves is from coastal development for urban use and sedimentation arise from mining (Spalding *et al.*, 2010)

*Compiled from various sources by CT Atlas team up to July 2012;
**UNEP-WCMC (2010) Global Distribution of Coral Reefs. Download from UNEP-WCMC's Ocean Data Viewer (http://data.unep-wcmc.org/datasets/13) and further correcting the topology error by CT Atlas team (2012);
***UNEP-WCMC (2010) Mangroves of the World 2010. Preliminary global dataset provided to ReefBase.

THAILAND

South China Sea

Peninsular
MALAYSIA

Sabah
MALAYSIA

BRUNEI

Sarawak
MALAYSIA

Sumatra
INDONESIA

SINGAPORE

Borneo
INDONESIA

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Number of **MPAs** (known boundaries)*		50 (49)
Total MPAs area (km²) for known boundaries		3,856ᵃ
MPAs in EEZ (%)		0.8
Coral Reef area (km²)**		1,687
Reef area in MPAs (km²)		157
Reefs in MPAs (%)		9
Mangrove area (km²)***		7,041
Mangrove area in MPAs (km²)		0.51
Mangrove in MPAs (%)		0.01

ᵃMissing spatial polygon for Miri Sibuti National Park in Sarawak (1,869km²). It would add up to total area of 5,725km².

❑ **MPA Management Authority:**
- Federal (Marine Park Department)
- State (Sabah and Sarawak government)
- Private company

❑ **Coral Reef:**
- Number of coral species (Veron *et al.*, 2009): 540
- Coral reefs is generally categorised as "fair", based on Average Percentage of Substrate Type Cover Recorded which valued 44.31% (ReefCheck, 2010) but it might declining with no further protection

❑ **Mangrove:**
- Number of mangrove species (Spalding *et al.*, 2010): 40
- Malaysia primarily lost about 16% ha of mangroves from 1980 to 2005 due to conversion of land for agriculture, shrimp ponds or urban development (FAO, 2007)
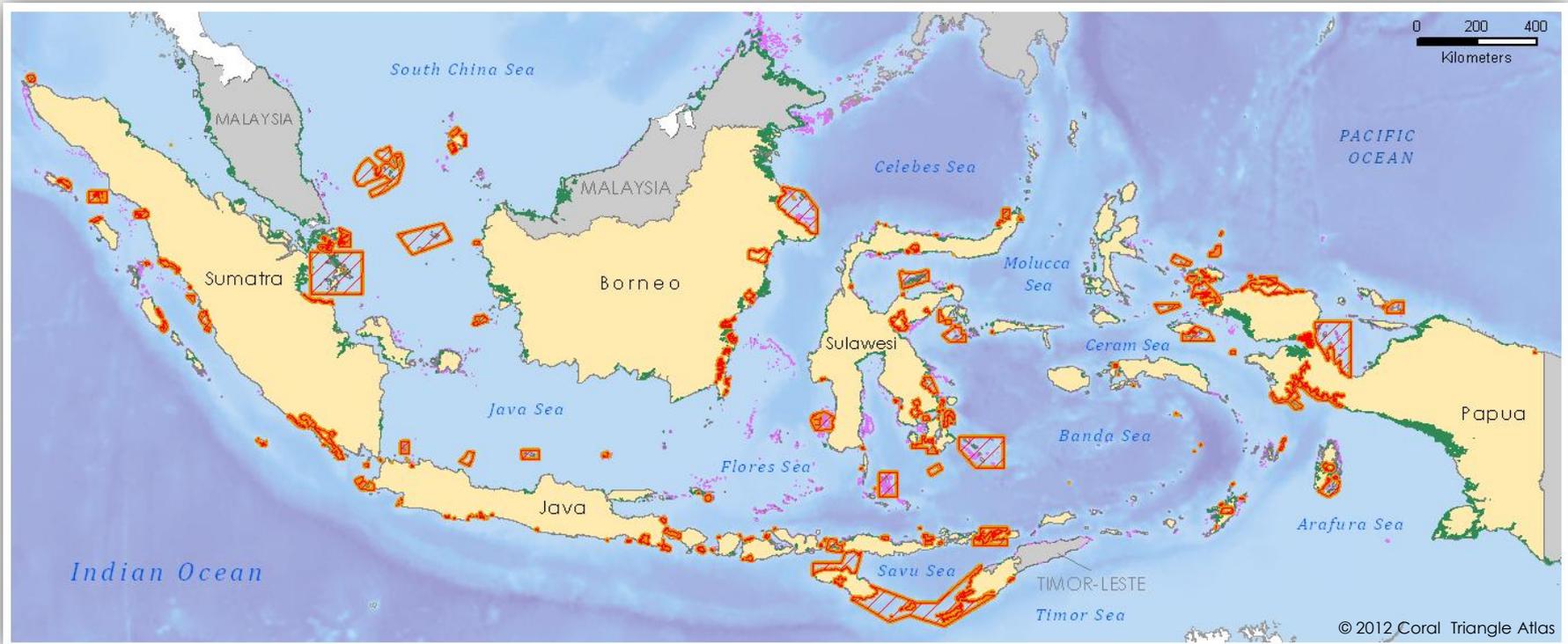
*Compiled from various sources by CT Atlas team up to July 2012;
**UNEP-WCMC (2010) Global Distribution of Coral Reefs. Download from UNEP-WCMC's Ocean Data Viewer (http://data.unep-wcmc.org/datasets/13) and further correcting the topology error by CT Atlas team (2012);
***UNEP-WCMC (2010) Mangroves of the World 2010. Preliminary global dataset provided to ReefBase.

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Number of **MPAs** (known boundaries)*		166 (166)
Total MPAs area (km^2) for known boundaries		187,221
MPAs in EEZ (%)		3.1
Coral Reef area (km^2)**		19,805
Reef area in MPAs (km^2)		6,291
Reefs in MPAs (%)		32
Mangrove area (km^2)***		29,631
Mangrove area in MPAs (km^2)		2,609
Mangrove in MPAs (%)		9

❑ **MPA Management Authority:**
- Directorate General for Marine Affairs, Coastal Areas and Small Islands
- Directorate General of Forest Protection and Nature Conservation Ministry of Forestry

❑ **Coral Reef:**
- Number of coral species (Veron *et al.*, 2009): 574

❑ **Mangrove:**
- Number of mangrove species (Spalding *et al.*, 2010): 45
- One of the world larger mangroves area and the largest in Asia (FAO, 2007)

*Compiled from various sources by CT Atlas team up to July 2012;
**UNEP-WCMC (2010) Global Distribution of Coral Reefs. Download from UNEP-WCMC's Ocean Data Viewer (http://data.unep-wcmc.org/datasets/13) and further correcting the topology error by CT Atlas team (2012);
***UNEP-WCMC (2010) Mangroves of the World 2010. Preliminary global dataset provided to ReefBase.