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Establishing a marine conservation baseline for the insular Caribbean

John E. Knowles [a,*], Emma Doyle [b], Steven R. Schill [a], Lynnette M. Roth [a], Amy Milam [c], George T. Raber [d]

[a] The Nature Conservancy, Caribbean Program, 255 Alhambra Circle, Coral Gables, FL 33134, USA
[b] Gulf and Caribbean Fisheries Institute, 2796 Oversees Highway, Marathon, FL 33050, USA
[c] United Nations Environment Programme World Conservation Monitoring Centre, 219 Huntingdon Road, Cambridge CB3 0DL, UK
[d] The Department of Geography and Geology, University of Southern Mississippi, 118 College Dr, Hattiesburg, MS 39406, USA

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ABSTRACT

Marine protected areas are a primary strategy for the conservation of marine habitats and species across the globe. In small island developing states, they often exceed their terrestrial counterparts in both number and area. To assess their effectiveness as a conservation measure over time, the accurate and up-to-date representation of marine protected areas through spatial and tabular data is imperative in order to establish baselines. Various regional and global agreements have set specific protection targets and these require spatial reporting on protected areas as an indicator of progress. For the insular Caribbean region, this study considers progress towards global Aichi Target 11 of the Convention on Biological Diversity which is to conserve at least 10% of coastal and marine areas, and progress towards the regional target of the Caribbean Challenge Initiative (CCI) to protect "at least 20% of nearshore marine and coastal habitats", both aiming for a 2020 deadline. Progress towards these targets differs widely depending on the accuracy of the datasets and the methods used. In an effort to update the current baseline of protection within the insular Caribbean, multiple governments, the Nature Conservancy and the Caribbean Marine Protected Area Management Network and Forum collaborated to develop a single insular Caribbean protected area dataset with accurate boundary information and the best available ecoregional and political boundaries. This study represents the most in-depth and spatially accurate effort to date to determine marine protected area coverage in the insular Caribbean. It is found that some form of marine management has been designated for around 7.1% of our study area in the insular Caribbean; progress towards Aichi Target 11 averaged among sovereign states within the insular Caribbean stands at approximately 3.25% and only three of the 10 participating governments in the CCI have reached their 20% target. Ocean protection was further assessed across the 25 governments and the three marine ecoregions by four different marine zones. Recommendations are made on regional to global cooperation for data sharing and reporting on indicators, highlighting possible directions to fill marine conservation gaps in the insular Caribbean.

1. Introduction

1.1. Background

The Caribbean is one of the world's most complex mosaics of marine and coastal habitats, comprising 10% of global coral reefs (26,000 km^2) [1]; 18% of global seagrass beds (66,000 km^2) [2]; and 12% of global mangrove forests (22,000 km^2) [3]. These highly diverse marine habitats provide ecosystem services, such as shoreline protection, and support livelihoods and economic activities, providing food security and underpinning tourism-based economies for the 43 million people living in the insular Caribbean. However, the health of these marine resources is rapidly deteriorating due to impacts such as unsustainable coastal development, overfishing, land-based and marine pollution, and climate change, threatening their ecological and economic value [1,4].

A variety of conservation mechanisms and strategies are available to resource managers to address the plethora of impacts on the insular Caribbean's marine ecosystems. Marine protected areas (MPAs) have gained increasing popularity as a strategy to conserve marine resources [5] and are typically implemented by civil society or through government action [6].

* Corresponding author.
E-mail addresses: jknowles@tnc.org (J.E. Knowles), emma.doyle@gcfi.org (E. Doyle), sschill@tnc.org (S.R. Schill), lroth@tnc.org (L.M. Roth), Amy.Milam@consultants.unep-wcmc.org (A. Milam), george.raber@usm.edu (G.T. Raber).

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1.2. Definitions

This study applies the IUCN protected areas categories and uses the International Union for Conservation of Nature (IUCN) definition of protected area as "a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" [7]. Marine protected area (MPA) was defined according to the IUCN as "any area of inter-tidal or sub-tidal terrain, together with its overlying water and associated flora, fauna, historical, and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment" [8]. Insular Caribbean MPAs are known by a variety of terms such as marine reserves, marine parks, marine managed areas, marine sanctuaries, fish sanctuaries, fisheries protection areas, environmental protection zones and protected seascapes, and this study includes these varying nomenclatures that share a common intent for marine protection.

1.3. Conservation targets

A key feature of Caribbean marine conservation has been the adoption of targets for protected area coverage. Globally, the Convention on Biological Diversity (CBD) has become the premier mechanism for setting MPA targets. In 2002, the Sixth Conference of the Parties of the CBD formalized the target by 2010 "to achieve a significant reduction of the current rate of biodiversity loss at the global, regional and national level as a contribution to poverty alleviation and to the benefit of all life on Earth" [9]. In the insular Caribbean, all governments except the United States of America are party to the CBD.

A number of reports on progress towards the achievement of MPA targets have been published [10–18]. Progressing slowly at a global scale, marine protection, at 3.4%, lags behind terrestrial protection at 15.4% [15]. In the Caribbean, regional reporting shows that MPA coverage is low when compared to global targets [10,11,15,19,20]. Consensus that the 2010 biodiversity targets had not been met led to Parties to the CBD adopting the Strategic Plan for Biodiversity and setting 20 new targets, named the Aichi Targets [21]. Of these, Target 11 states that "by 2020, at least 17% of terrestrial and inland water areas, and 10% of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes" [22].

In the Caribbean, several national governments, donors and conservation organizations are seeking to accelerate regional progress towards biodiversity conservation through the endorsement of the Caribbean Challenge Initiative (CCI) that was launched in 2008 to build political support and generate long-term funding for marine conservation. At the CCI Summit of Political and Business Leaders in 2013, CCI participants declared the overarching goal "to support the conservation and sustainable use of biodiversity for the maintenance of critical ecosystem services provided by marine and coastal resources, that support livelihoods and the economic and social future of the countries and territories of the Caribbean through the Caribbean Challenge Initiative." The "20-by-20" goal seeks in each participating country and territory to effectively *conserve and manage at least 20% of the nearshore marine and coastal environment*. As of 2015, 10 governments have endorsed the Caribbean Challenge Initiative including The Bahamas, Dominican Republic, Jamaica, Puerto Rico, the United States Virgin Islands (USVI), the British Virgin Islands (BVI), Saint Kitts and Nevis, Saint Lucia, Grenada and Saint Vincent and the Grenadines [23].

1.4. Geographic scope of this study

This article reports on the status of coastal and marine protection in the insular Caribbean defined by 25 island governments and three marine ecoregions. The total study area (Fig. 1) includes the combined areas under national jurisdiction of the 25 island governments and the Bahamian, the Greater Antilles and the Eastern Caribbean marine ecoregions. This area encompasses the islands of the Lucayan Archipelago, the Greater Antilles and a majority of the Lesser Antilles stretching from the United States (US) and British Virgin Islands down to Grenada.

The relationship between MPA size and sovereignty was examined, with non-sovereign states being the dependent territories and/or integral overseas territories of the US (Puerto Rico and USVI), the United Kingdom (Anguilla, BVI, Cayman Islands, Montserrat and the Turks and Caicos Islands), France (Guadeloupe, Martinique, Saint Martin, Saint Barthélemy) and The Netherlands (Sint Maarten, Saba and Sint Eustatius only). The insular Caribbean's sovereign states were defined as large or small according to the common benchmark of 1.5 million people. The large sovereign states included in this study are Cuba, the Dominican Republic, Haiti and Jamaica. The small sovereign states include Antigua and Barbuda, The Bahamas, Barbados, Dominica, Grenada, Saint Lucia, Saint Kitts and Nevis, and Saint Vincent and the Grenadines. Population numbers were drawn from the 2012 Revision of the World Population Prospects of the United Nations.

2. Methods

Spatially explicit protected area datasets are at the foundation of reporting progress towards the achievement of MPA targets, enabling tracking of the extent to which marine resources are conserved. At the global level, MPAs have been mapped through the joint efforts of the United Nations Environment Programme's World Conservation Monitoring Centre (UNEP-WCMC) and the IUCN, which compiles global protected area information in the World Database on Protected Areas (WDPA). Stemming from the United Nations List of National Parks and Equivalent Reserves in 1962 (subsequently renamed the United Nations List of Protected Areas) the WDPA is the only comprehensive global inventory of the world's protected areas [7,14,24,25]. It is made-up of a mosaic of regional, national and sub-national datasets sourced from authoritative data providers responsible for the governance and management of protected areas in every country and across regional protected area conventions. The WDPA is used as the baseline dataset on protected areas for global analyses such as the UN Millennium Development Goals (MDGs) and biodiversity indicators of the CBD as well as in other assessments [10,19,26,15,17].

In the Caribbean, the first attempt to spatially document and create an inventory of MPAs was made at a workshop in 1988 hosted by the US National Oceanographic and Atmosphere Administration and the Organization of American States [27]. This provided the first official MPA baseline for the Caribbean. The Caribbean Marine Protected Area Management Network and Forum (CaMPAM) MPA Database was established in 2000 under the framework of the Caribbean Environment Programme of the United Nations Environment Programme and the Specially Protected Areas and Wildlife Protocol of the Cartagena Convention and is hosted online (http://campam.gcfi.org/CaribbeanMPA/CaribbeanMPA.php) by the Gulf and Caribbean Fisheries Institute. However, there was no regional coordination or maintenance of a geographic information system (GIS) database of Caribbean

MPAs until the Nature Conservancy (TNC) began an ecoregional assessment in 2003 [28].

TNC's Caribbean Program began to build the insular Caribbean protected area dataset using a subset of the 2004 WDPA and working collaboratively with protected area experts across 25 island governments to identify and confirm the actual demarcation of existing protected area boundaries. Missing protected area boundaries and attributes were added to the dataset. This was continually compared with later versions of the WDPA and as more accurate or up-to-date information became available it was incorporated into the dataset used for this assessment. At the time of publication, this dataset provides the most detailed and accurate dataset from which to measure progress toward targets for MPA coverage in the insular Caribbean.

The insular Caribbean protected area dataset is being maintained in shapefile format and all updates made using Esri™ ArcGIS software. Five datasets used for the study include shoreline, depth, marine ecoregions, exclusive economic zones (EEZ), and MPA boundaries. The Prototype Global Shoreline Dataset, a product of the National Geospatial Agency's (NGA) Office of Global Navigation, Maritime Domain [29] provides the most accurate global shoreline dataset (1:75,000 scale). The shoreline was digitized from orthorectifed Landsat 7 satellite imagery and represents the high water line with a reported accuracy of 50 m (RMS). All depth measurements were taken from the General Bathymetric Chart of the Oceans (GEBCO) dataset [30], the most accurate, publicly-available bathymetry dataset for the world's oceans. The study used the GEBCO_08 Grid—a global 30 arc-second grid largely generated by combining quality-controlled ship depth soundings with interpolation between sounding points guided by satellite-derived gravity data. The Bahamian, the Greater Antilles, and the Eastern Caribbean ecoregions were extracted from the global classification of Marine Ecoregions of the World (MEOW) [31–33]. The EEZ is the marine extent prescribed by the United Nations Convention on the Law of the Sea, which typically extends to a distance of 200 nautical miles from a state's coastal baseline [34]. National and territorial boundaries were provided by the Flanders Marine Institute (*Vlaams Instituut voor de Zee*), with a modification made to this dataset to accurately reflect the actual boundary between Grenada and St. Vincent and the Grenadines.

Within the GIS, MPAs were first determined by applying the IUCN MPA definition using the NGS shoreline file. This preliminary output was refined by the intent of the protected area, determined through local knowledge, the protected area name and/or legal definition to ensure that the true intent of the law or means to protect the environment included a marine component. Once selected the MPA boundaries were clipped by the NGA shoreline file in order to calculate water only area. A correction was applied to the boundaries of the Dominican Republic's Marine Mammal Sanctuary of Silver and Christmas Banks and Estero Hondo Marine Mammal Sanctuary, which were found to enter the territorial EEZ of the Turks and Caicos Islands. Communication with MPA managers in the Dominican Republic and the Turks and Caicos Islands indicated that management of these MPAs does not cross international borders so the MPA boundaries were corrected to align

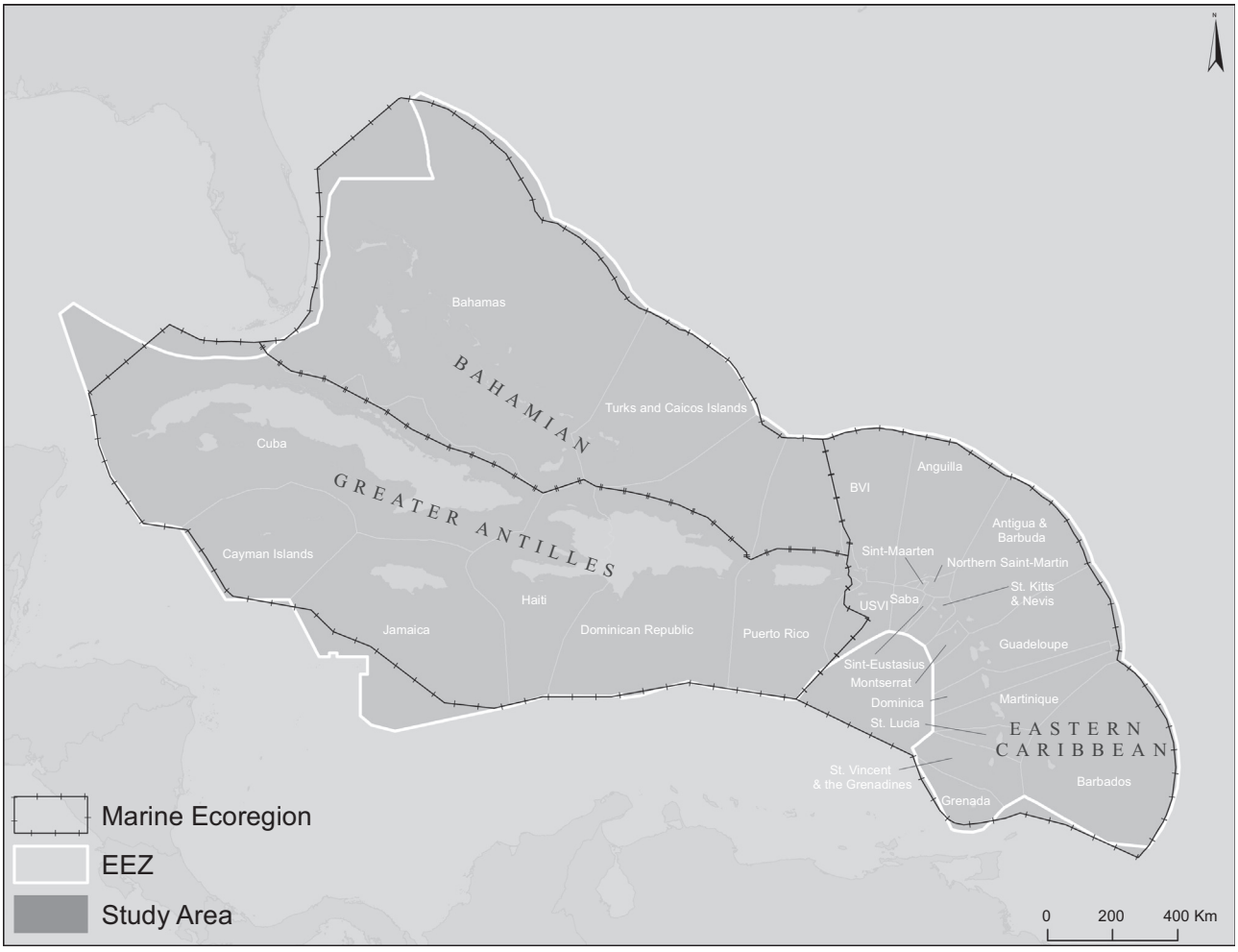

Fig. 1. Map of the ecoregions of the insular Caribbean, EEZs and study area.

with the EEZ of the Dominican Republic. Additional attributes used in the assessment included the date the MPA was established and IUCN category. In the case of overlap, where more than one establishment date and IUCN category was assigned for the same area the earlier date and strictest classification was counted towards the analysis.

MPA extent was calculated for each EEZ, by marine ecoregion and for the groupings of small and large sovereign states and non-sovereign states. As a further level of classification of ocean protection, four marine zones were defined (Fig. 2). Three of the four marine zones used in this study are defined by depth: nearshore, shelf and oceanic [35,36]. "Nearshore" extends from the shoreline to the 30 m depth contour. "Shelf" extends from the shoreline to the 200 m depth contour, overlapping "nearshore." "Oceanic" incorporates all areas deeper than 200 m depth. The fourth zone included in this study is "nursery habitat," which is not defined by depth. Rather, this zone represents the different marine habitats, species and processes that would be diminished in terms of scale if only reported by depth. This zone overlaps with the nearshore and shelf zones and was created within a GIS, considering all coastal areas within a distance of 100 m from the shoreline including all bays and estuaries with mouths or openings less than or equal to 6 km.

Since 2004, the Programme of Work on Protected Areas (PoWPA) has encouraged parties to the CBD to develop and manage ecologically representative networks of protected areas on land and sea. To date, 8 of 13 Caribbean sovereign states that are signatory to the CBD have submitted national biodiversity strategies and action plans to fulfil the PoWPA which includes MPA gap assessments involving habitat inventories, threat evaluations and goal setting exercises. However, interpretation by the countries is allowed in how the Aichi Targets are set, including Target 11. Thus, at a national level, the 10% of "coastal and marine areas" could refer to territorial seas or coastal waters (0–12 nautical miles), area under national jurisdiction (0–200 nautical miles) or any other zonation that may fall within the EEZ. At the global level, this target is calculated for the world's ocean, however it is also reported out by coverage in coastal waters, areas within national jurisdiction and areas beyond national jurisdiction [15]. Unfortunately, the majority of sovereign states in the insular Caribbean have not indicated within their action plans what specifically they are measuring their targets against. Given this reason, along with the fact that on a global average the Aichi 11 target has already been met within coastal waters (0–12 nautical miles) [15] and there are no areas beyond national jurisdiction in the Caribbean, this study applied MPA coverage by EEZ to indicate achievement by governments of the Aichi 11 target of 10% protection of marine and coastal areas. Similar to the Archi 11 target, setting the CCI target is also interpreted by the governments. In all but 3 exceptions, MPA coverage in the shelf zone is indicative of achievement of the CCI target to conserve and manage at least 20% of the marine and coastal environment in participating countries and territories. The first exception includes the Bahamas, which is considering setting its CCI target as 20% of EEZ, exceeding the Aichi 11 target. The other two exceptions include Puerto Rico and the USVI, which measure progress towards the CCI within their territorial waters (0–9 and 0–3 nautical miles, respectively).

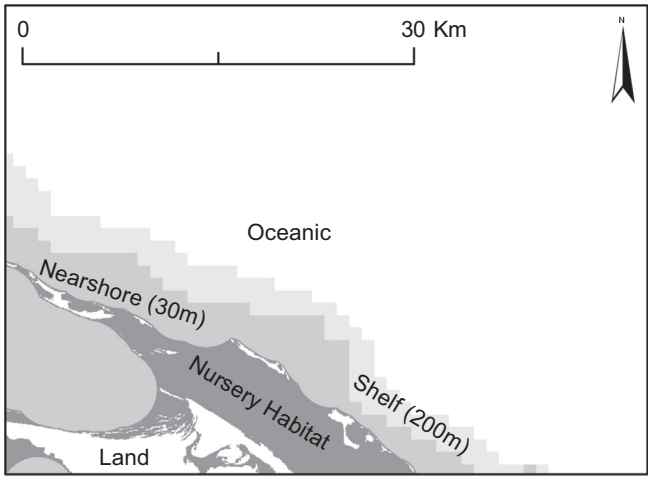

Fig. 2. Depiction of marine zones applied in the study.

3. Results

3.1. The findings on the current status of MPA coverage in the study area can also be viewed online at www.caribbeanchallenge.org

3.1.1. General findings

Within the study area, there is 52,520 km of shoreline length, 22,652 km^2 of nursery habitat, 232,449 km^2 in the nearshore zone (0–30 m depth), 302,226 km^2 in the shelf zone (0–200 m), and 3138,839 km^2 in the oceanic zone (> 200 m). Within this area, 376 marine protected areas were identified covering 245,566 km^2 of marine waters. This is equivalent to 7.1% MPA coverage of marine and coastal areas in the study area. Of the 25 governments included in this study, Cuba has the most declared MPAs ($n=54$). Only Montserrat and Saint Kitts and Nevis have yet to establish any MPAs (Fig. 3). The MPA coverage among the sovereign states within the insular Caribbean is at approximately 3.25%.

Of the MPAs in the insular Caribbean, about 84% of them are 100 km^2 or smaller (Fig. 4). On average, an MPA in the insular Caribbean is 737 km^2 and the median size is 11 km^2. The smallest MPA in the insular Caribbean is Frenchman's Cay (0.0035 km^2) in the BVI and the largest is the Agoa Sanctuary (Santuaire Agao) of the French territories (143,256 km^2). Seventy-three MPAs in the insular Caribbean are more than 100 km^2 in size.

On average, MPA size for large sovereign states is larger than small sovereign states (Fig. 5). A few governments break from this trend due to the designation of a single large MPA. For The Bahamas, it is the Westside Andros National Park. For the French territories, it is the Agoa Sanctuary. And for the Dutch Territories, it is the Saba Bank National Park. The average MPA size for the non-sovereign states is skewed due to the Agoa Sanctuary. Removing this MPA would generate an average MPA size between 47 km^2 and 582 km^2.

3.2. Progress towards Aichi Target 11

For the insular Caribbean's sovereign states, Fig. 6 shows progress towards Aichi Target 11 of 10% MPA coverage of coastal and marine areas in each EEZ. The Dominican Republic is the only sovereign state that has declared protected areas for more than 10% of its EEZ (16.16%) and has thus achieved Aichi Target 11. Cuba has the next highest level of MPA coverage of its EEZ among sovereign states at 4.07%, still well below the target. The Bahamas has the largest EEZ of all 25 governments included in this study and is third among sovereign states with MPA coverage of 0.67% of its EEZ. Of the small sovereign states with MPAs, the lowest MPA coverage of EEZ is in Barbados (0.01%) followed by Dominica and Grenada (both 0.04%).

The level of protection afforded to coastal and marine areas by the dependent territories of the Caribbean all are below the 10% target for areas within national jurisdiction, except for the French Territories with the Agoa Sanctuary, as shown in Fig. 7. Applying EEZ boundaries to all non-sovereign states except for the French

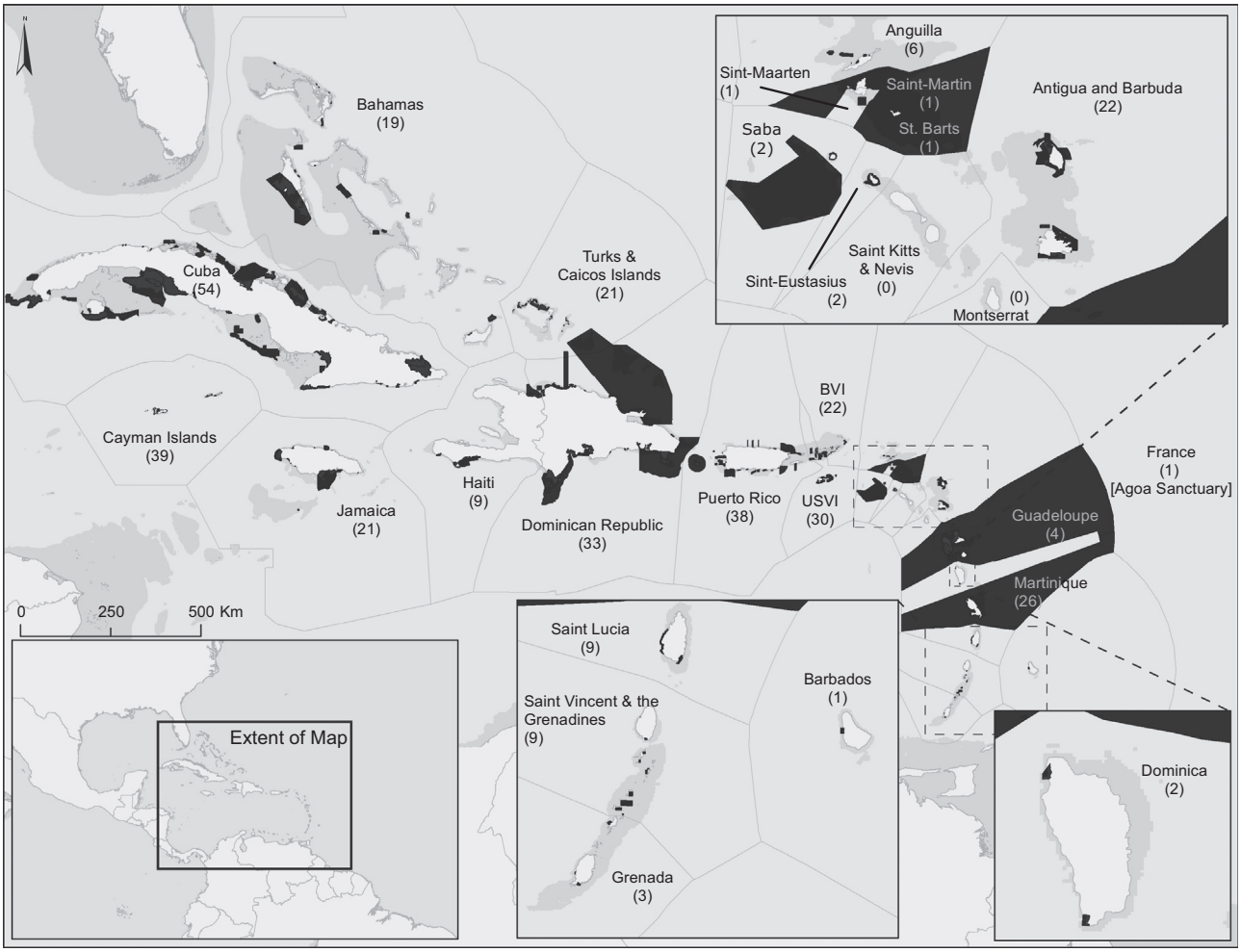

Fig. 3. Map of the insular Caribbean showing the 200 m-depth shelf (darker gray), EEZ jurisdictions and MPA boundaries shown in dark polygons ($n=376$). Inside parentheses is the MPA number for each government.

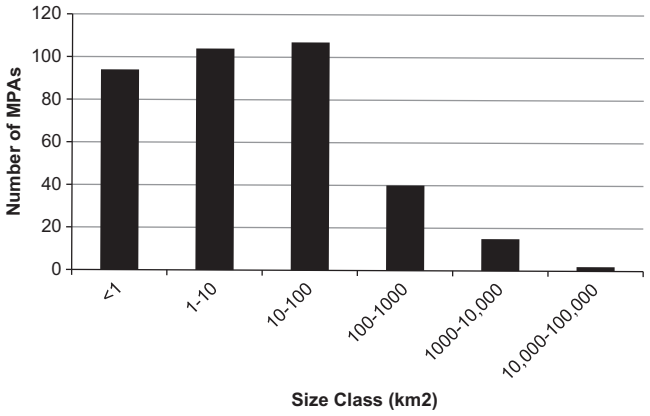

Fig. 4. Size frequency distribution of MPA size within the insular Caribbean.

territories, Saba is the only non-sovereign state that has declared protected areas for more than 10% of its territorial EEZ (28.11%). Of the non-sovereign states with MPAs, Anguilla has the lowest MPA coverage at 0.03% of territorial EEZ.

3.3. Progress towards 20% MPA coverage of shelf

Fig. 6 can be used to assess how sovereign states are progressing towards the smaller target of 20% MPA coverage of shelf. For six of the sovereign states in Fig. 6, this is their declared target towards 20% protection of marine and coastal areas as a CCI participant. The Dominican Republic is the only sovereign state and CCI participant that has MPA coverage of more than 20% of its shelf (72.15%). Although not a participating CCI government, Cuba is the next closest sovereign state to the 20% of shelf target at 19.88% MPA coverage. Among the sovereign state CCI participants that have declared MPAs, currently furthest from the CCI target is Grenada (0.4%). With the Bahamas considering setting its CCI target as 20% of EEZ, this would only further establish it as the government with the highest overall target in terms of area in the insular Caribbean. Among the three non-sovereign state CCI participants, only two have at least 20% MPA coverage of the shelf, Puerto Rico and the USVI (Fig. 8). These two governments have also achieved their CCI target, being interpreted as 20% of their territorial waters. The remaining non-sovereign state CCI participant, the BVI, has a 1.71% MPA coverage of the shelf (Fig. 8).

Although not participating in the CCI, all French territories in the insular Caribbean have surpassed the 20% MPA coverage target with the designation of the Agoa Sanctuary. This list also includes Saba, Turks and Caicos and Saint Eustatius at 96.45%, 29.97% and 26.15% MPA coverage of the shelf, respectively.

3.4. Marine zone representation

Fig. 9 displays the results of marine zone representation among MPAs in the insular Caribbean. Among the total group of island governments, nursery habitat has the highest proportional level of

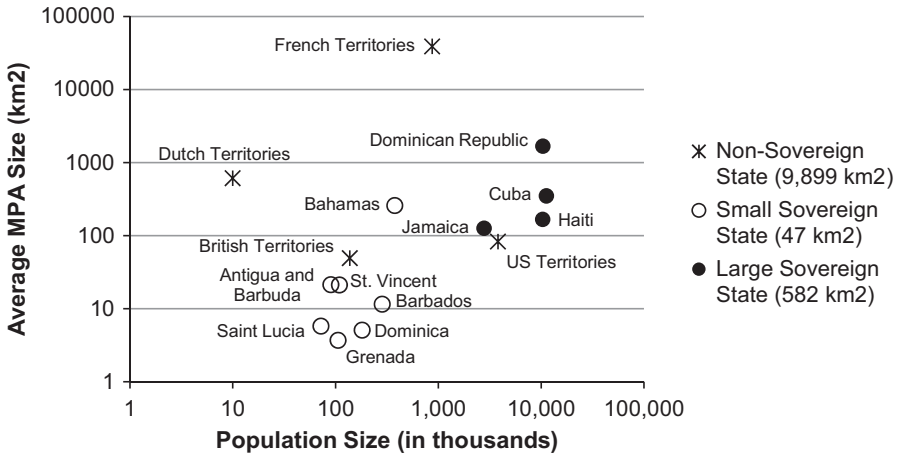

Fig. 5. Comparison of MPA size and population size in the insular Caribbean for governments that have MPAs. Inside parentheses is the average MPA size for each sovereignty group.

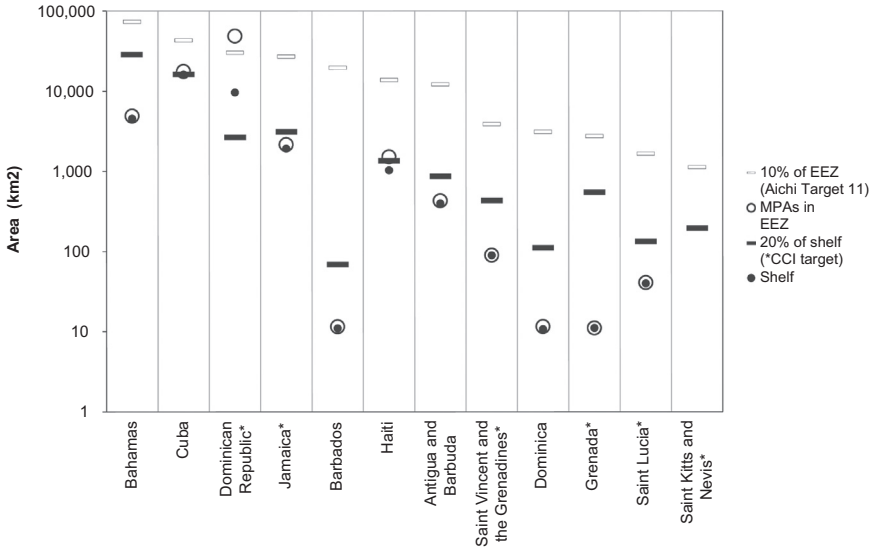

Fig. 6. Progress towards Aichi Target 11 by sovereign states and 20% of shelf.

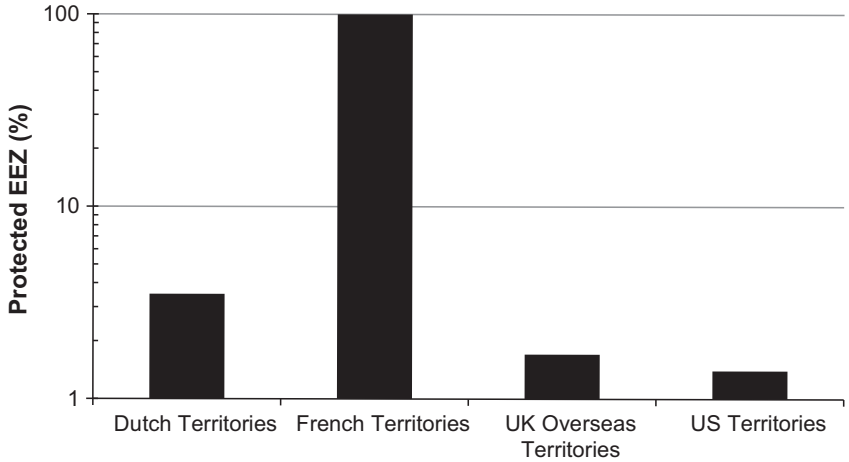

Fig. 7. MPA coverage of combined EEZ for territories which generally represents areas beyond non-sovereign state government jurisdiction.

protection at 39.43% MPA coverage in the total study area. Of note, more than 50% of nursery habitat is decreed as protected in Jamaica (70.25%), the Dominican Republic (67.17%), Antigua and Barbuda (72.61%), and the French territories (100%). The nearshore zone has 13.35% MPA coverage in the total study area. The shelf zone similarly has 15.57% of its area decreed as protected. The oceanic zone is least protected in the insular Caribbean, with only 6.64% MPA coverage in the total study area. Of the sovereign states,

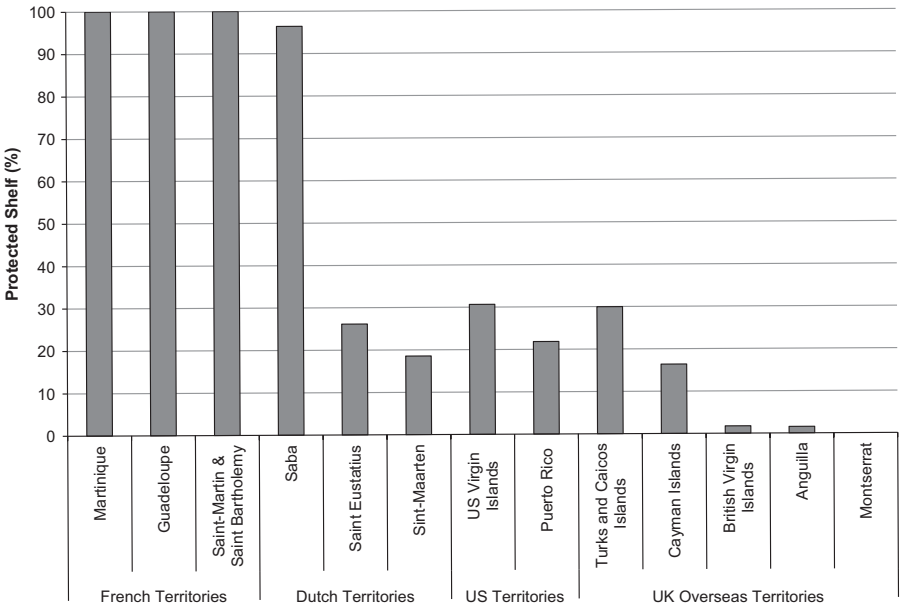

Fig. 8. MPA coverage of shelf for non-sovereign states which generally represents areas within the governments' jurisdiction.

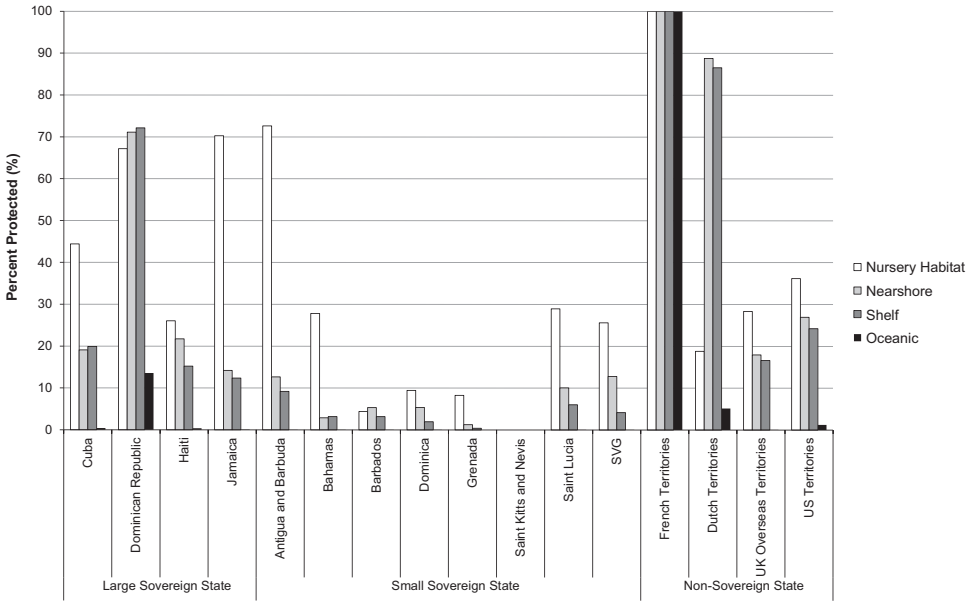

Fig. 9. Comparison of ocean protection by marine zone.

the Dominican Republic affords the most protection to the oceanic zone, with 13.56% MPA coverage in waters deeper than 200 m. The Agoa Sanctuary for the French territories covers 100% of all zones.

Comparing the level of MPA coverage and marine zone representation between ecoregions (Fig. 10), it is evident that protection of all zones is highest in the Eastern Caribbean ecoregion, largely due to the Agoa Sanctuary. All ecoregions achieve their highest MPA coverage in nursery habitat. The Bahamian ecoregion has the lowest total percent MPA coverage.

3.5. Number vs. area of MPAs

Having more MPAs does not necessarily translate to greater MPA coverage, as observed by the ecoregion analysis in Fig. 11. The Greater Antilles ecoregion has the greatest number of MPAs, where the Eastern Caribbean ecoregion has the most MPA coverage. The majority of MPA area coverage in the insular Caribbean is a result of 5 large MPAs. The majority of MPA coverage within the Bahamian ecoregion is due to a portion of an MPA that originates in a country not squarely in that ecoregion (i.e. Dominican Republic).

3.6. IUCN category findings

IUCN categories have been assigned to 255 MPAs compared to 121 MPAs not having an assigned IUCN category in the insular Caribbean, which represents 69% of area of MPAs, shown as 'Unknown' in Fig. 12. This large percentage is mainly due to Agoa Sanctuary not having an assigned IUCN category. The IUCN category with the greatest coverage is 'Ib Wilderness Areas' (16%), largely attributed to the marine mammal sanctuary in the Dominican Republic having been assigned this category. Removing both of these sanctuaries, the IUCN category with the greatest coverage then becomes 'IV, Protected Landscape/Seascape' (35%)

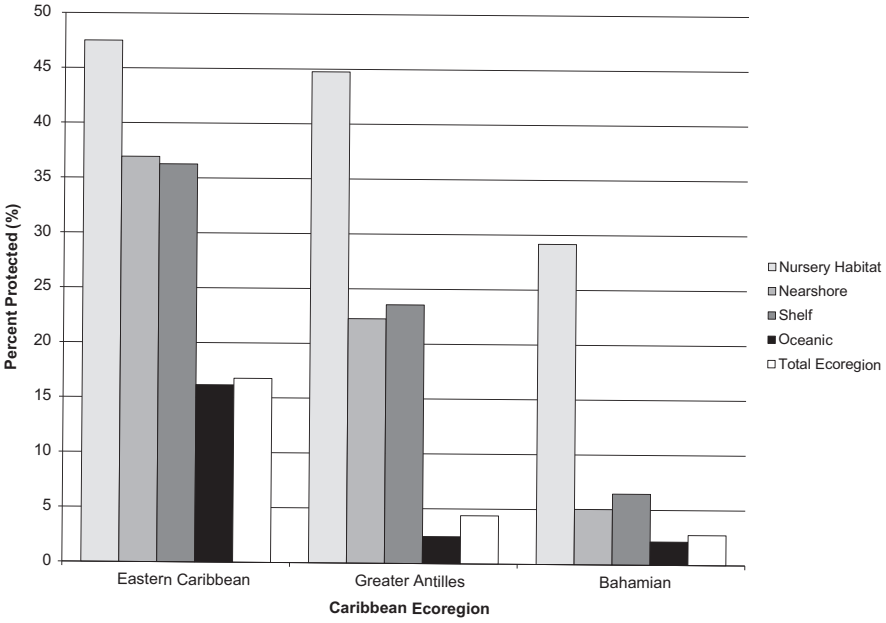

Fig. 10. Comparison of marine zone representation in MPAs by ecoregion.

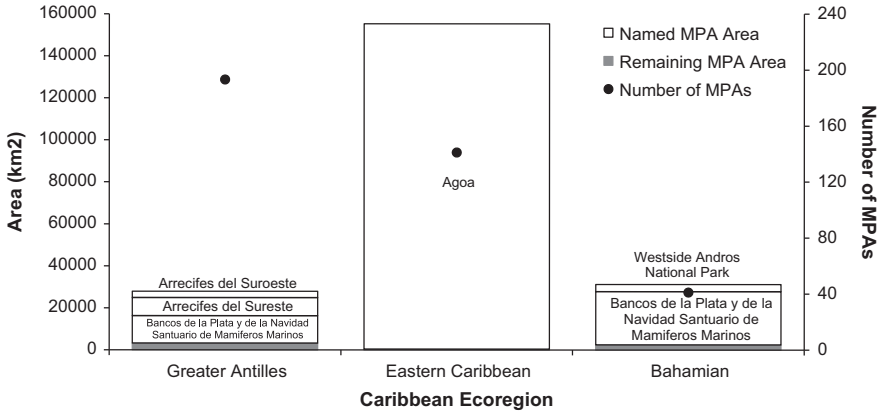

Fig. 11. Comparison of MPA coverage in each marine ecoregion of the insular Caribbean, as area (bars) and number (points). The five largest MPAs are shown separately.

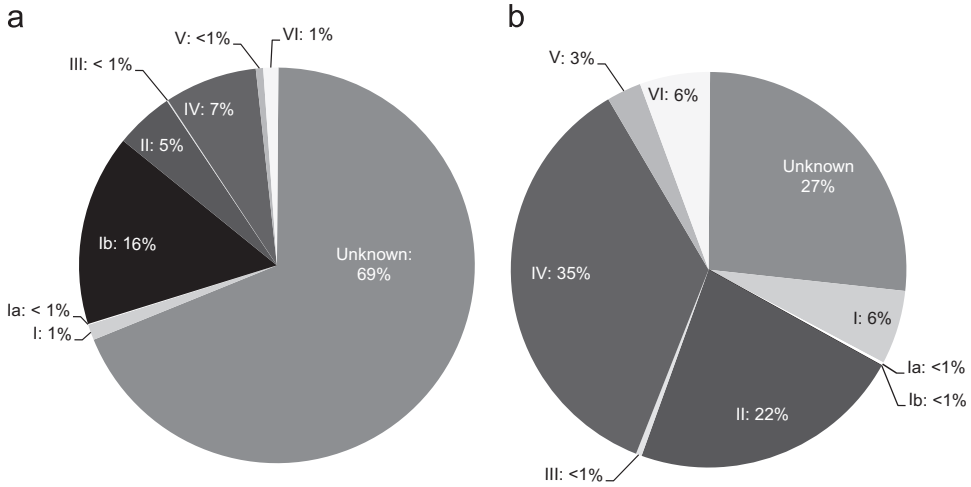

Fig. 12. IUCN categories by area of MPAs in the insular Caribbean (a) including the Dominican Republic's marine mammal sanctuary and the Agoa Sanctuary of the French territories and (b) excluding these same two sanctuaries given their large sizes compared to all other MPAs. IUCN categories includes; Category I: PA managed mainly for science or wilderness protection (Ia Strict Nature Reserves, and Ib Wilderness Areas), Category II: PA managed mainly for ecosystem protection and recreation (National Park), Category III: PA managed mainly for conservation of specific natural features (Natural Monument), Category IV: PA managed mainly for conservation through management intervention, Category V: PA managed mainly for landscape/seascape conservation and recreation (Protected Landscape/Seascape), Category VI: PA managed mainly for the sustainable use of natural ecosystems (Managed Resource PA) [7].

followed by 'Unknown' (27%) followed by 'II National Park' (22%). The remaining IUCN categories represent 6% or less as a portion of total area of MPAs.

3.7. Increase of MPAs overtime

Since the 1970s, both the number and cumulative area covered by MPAs in the insular Caribbean has risen steadily (Fig. 13). The 5 biggest years to date for the establishment of MPAs by number were 1986 (with 31 MPAs established that year), 1987 (with 24 MPAs established), 1993 (with 27 MPAs), 2003 (25 MPAs) and 2010 (26). In 1986, the year with the most MPAs established, the Marine Mammal Sanctuary of Silver and Christmas Banks came into existence in the Dominican Republic, along with 30 more MPAs across the region, the majority in the Cayman Islands. In 1987, the sharp increase in declaration of MPAs involved six governments with the majority of those MPAs in the Turks and Caicos Islands and Saint Vincent and the Grenadines. In 1993, the spike links to six MPAs designated in Anguilla, the declaration of the Red Hind Spawning Aggregation Areas West of Puerto Rico and the establishment of 18 "Area[s] of Particular Concern" and two "Offshore Fishing Closures" in the USVI. In 2003, the spike is attributable to MPA designation by five governments, the majority of those being in the British Virgin Islands. In 2010, the Agoa Sanctuary was established by France for the French territories, along with 25 more MPAs designated in the region that year, the majority being from Cuba.

Spikes in the cumulative area covered by MPAs occurred in 1996, 2004, 2009 and 2010. The spikes in cumulative area in 1996 and 2004 were driven by the expansion of the Marine Mammal Sanctuary of Silver and Christmas Banks in the Dominican Republic [37]. In 2009, the Dominican Republic also drove the increase in area of MPAs with major new declarations. In 2010, the insular Caribbean saw the highest jump in marine area designated as protected, approximately 166,000 km^2. Again, it was this year that Cuba declared 18 MPAs and France established the Agoa Sanctuary. By the end of 2010, a total of 332 MPAs had been formally declared in the insular Caribbean, covering an estimated 236,439 km^2, an increase of 528% over the previous 10 years.

Simple linear regression of the cumulative MPA coverage indicates a 0.179% increase each year over 1986–2014. This timespan was selected to begin at 1986 as this is the year the highest numbers of MPAs were established in the insular Caribbean and when the marine mammal sanctuary of the Dominican Republic was established, what could represent the beginning of the modern era for MPAs in the insular Caribbean. The perspective of a shorter timeframe from 2006, the year the MPA target was set for the CBD, to present, MPA growth is higher at 0.9% per year (Fig. 14).

4. Discussion

4.1. General findings

This study represents the most in-depth and spatially accurate effort to date to determine MPA coverage in the insular Caribbean. We have shown that MPA coverage overall for the insular Caribbean is below the key conservation targets associated with the CBD and CCI for the year 2020. Achievement of the Aichi Target 11 is limited, with only one out of eight Caribbean countries that have submitted PoWPA action plans having so far achieved 10% MPA coverage in their EEZ. Similarly, achievement under the CCI is limited, with only three of 10 CCI participants having so far achieved their 20% MPA coverage target.

However, compared with the reference value of 8.4% of all marine areas within national jurisdiction covered by protected areas globally [15], MPA coverage across the total insular Caribbean is not far behind at 7.1% for our study area. However, among just the sovereign states within the insular Caribbean, the MPA coverage is much lower at approximately 3.25%. Conversely, this is better than the reported percentage of 1.2% within national jurisdiction (0–200 nautical miles) for the Caribbean region by Juffe-Bignoli [15] (which included Aruba, Bonaire, Curacao and Bermuda). The uneven distribution of MPA coverage across the marine zones of the insular Caribbean is broadly consistent with other reports [11,15,38] whereby shallow water is better protected (39.43%, 13.35% and 15.57% MPA coverage respectively for the nursery habitat, neashore and shelf zones of the insular Caribbean)

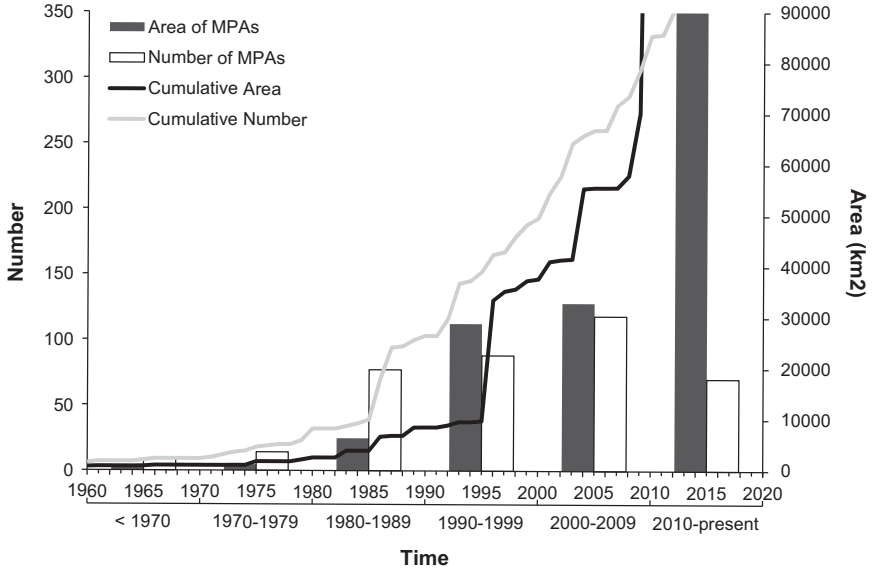

Fig. 13. Number of MPAs and area covered by MPAs in the insular Caribbean from 1960 to 2014. Bars show number and area of MPAs established within each time period (lower axis labels). Lines show cumulative area and number of MPAs from 1960 until present. Not all MPAs contributed to the area calculations as some were established inside an already existing MPA. (Number: $n=376$; Area: $n=364$).

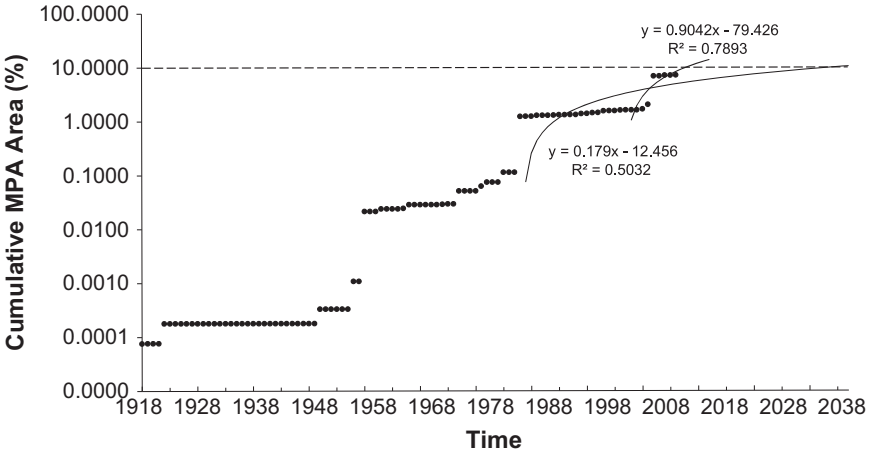

Fig. 14. Cumulative MPA coverage as percent over time with projections of percentage increase using two different timespans (1986–2014 and 2006–2014).

than deeper water (6.64% MPA coverage for the oceanic zone in the insular Caribbean).

4.2. Large MPA size

MPA size will determine the rate at which a government or region meets its conservation target and is argued to be an important aspect of increasing conservation benefits [39,40]. The declaration of relatively large areas does represent a quick way to meet coverage goals [39]. For example, the largest MPAs in the insular Caribbean (the marine mammal sanctuaries of the Dominican Republic and the French territories) represent about 80% of the MPAs by area. Removing them would drop MPA coverage in the study area from 7.1% to just above 1%.

However, these large MPAs are the exception in the insular Caribbean leading Deguignet et al. [16] to state that "relatively low marine coverage of the Caribbean region is explained by the small area of the marine reserves" (p. 14). Essentially, effective coverage would be a function of number of MPAs. If this is the case, certain governments are going to struggle meeting conservation targets more than others. Our results show that on average, MPA size for large sovereign states is larger than small sovereign states. It can only be hypothesized whether this might be linked with a perspective of scale between large and small states or linked with greater management capacity for conservation among larger populations or, as suggested by Butchart et al. [17], linked to GDP, which our study did not look at. However, a few governments have broken from this apparent trend by establishing just one large MPA (e.g. The Bahamas through the Westside Andros National Park, the Dutch territories through Saba Bank National Park and the French Territories through Agoa Sanctuary).

These larger declarations not only represent a quick way to meet coverage goals, it is likely they are the only way that coverage goals are obtainable in the insular Caribbean in the first half of this century. Using the percentage increase per year for the timespan 1986–2014, the Caribbean would not meet the 10% MPA coverage until 2043. This is earlier than the first global predication at 2067 set by Wood et al. [10]. However, the more recent prediction by Spalding et al. [26] suggests that the 10% target is within reach globally by 2020 due the recent establishments of very large MPAs. Projecting over the shorter timespan (2006–2014), the insular Caribbean could meet a 10% target regionally before 2020. This projection, of course, assumes larger MPA declarations are more frequent and such a declaration would have to occur, but would only have to equal an area of about 100,000 km^2 (roughly equivalent to the EEZ of Anguilla) for the study area to reach 10% MPA protection.

Although the practicality of encouraging very large MPAs might be considered in the insular Caribbean, the region is likely to benefit from an increase in designation of MPAs of 100 km^2 or larger due in part to the exponential raise of conservation benefits that could be incurred [40]. Our findings indicate that less than one-fifth or only 73 MPAs in the insular Caribbean meet this criterion. Added to this, few insular Caribbean MPAs have been designed on the basis of ecological networking principles [41], which increases the risk that a series of small MPAs will not adequately protect critical habitat. Certainly, larger MPAs could help support migratory species that are found in the insular Caribbean, such as marine mammals, migratory birds, whale sharks and sea turtles. Larger MPAs could also help ensure improved ecosystem based management by more fully integrating marine and coastal ecosystems into protection.

We do agree with Spalding et al. [26] and De Santo [42] that although basic statistics about MPA coverage are required to measure progress towards goals and targets set under protected areas initiatives, they certainly should not be seen as the only measure for conservation. Beyond the coverage element, the complete goal set by Aichi Target 11 is to protect "areas of particular importance for biodiversity and ecosystem services … conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas"[22].

4.3. CCI

Currently, the CCI includes 10 governments committed to changing the status quo of slow progress towards closing the gap in marine conservation, supporting various elements of the Aichi Target 11, through three broad objectives to: (a) galvanize high-level political will to protect and effectively manage marine and coastal resources; (b) mobilize funding and put in place sustainable funding mechanisms; and (c) accelerate and support on-the-ground action to implement the commitments made by governments. As a challenge among participants and to other governments in the insular Caribbean, the principal objective of the CCI is to build a region-wide cooperative framework that provides public and private sector support coupled with sustainable financing for long-term and effective management of Caribbean marine resources. While meeting the MPA coverage target of the CCI falls well short of meeting the Aichi Target 11 for MPA coverage (except for maybe the Bahamas), and while sustainable financing and stronger political will do not guarantee that marine areas will be effectively conserved, these enhanced enabling conditions will increase conservation awareness within governments, mobilize additional funding, and facilitate scientific, policy,

and technical collaboration that will provide a higher chance of changing the status quo.

4.4. MPA network of people

An effectively and equitably managed system of protected areas does rely on the existence of regional and sub-regional networks of MPA management and managers that promote meaningful collaboration. The finding of a predominance of small MPAs across the insular Caribbean serves to underline the importance of networking MPA managers across international boundaries in order to build capacity for MPA management and to share best practices. We thus highlight targeted capacity building in MPA management, networking of MPAs and sharing of best practices as fruitful areas for international cooperation. Such capacity building would likely benefit and support the effort towards the establishment of larger MPAs as well.

4.5. Management objectives

Our analysis shows, after removing the two large marine mammal sanctuaries, that the largest proportion of MPAs is assigned to IUCN Category IV, meaning managed mainly for conservation through management intervention. The proportion of management objective classification can help regional and national planners balance the different objectives across a system [43,44]. Currently, MPA practitioners are more cognoscente of principles of livelihood options and coral reef restoration is becoming a higher profile element of MPA management in the insular Caribbean. Based on these two trends, it would seem likely that a future repeat of our analysis will see an increase in MPAs in categories V and VI, with a greater focus on sustainable management.

Notable in this study is the finding of a small proportion of strict nature reserves, which is indicative of a relative scarcity of no-take MPAs in the insular Caribbean. Yet Caribbean and global research indicates that no-take zones bring important benefits to marine ecosystems, especially for the recovery of exploited species, recruitment and spillover [45] and are also critical aspects to consider in assessing the larger conservation picture [46–49]. Considered together with the tendency towards small MPAs and the often limited effectiveness of MPA enforcement in the region, this shortage of no-take zones brings into question the actual management effectiveness of marine protection in the insular Caribbean, which the IUCN categories do not address. We recommend a greater focus on the establishment and effective management of MPAs in IUCN Category I(a) representing no-take zones [50]. This will continue to be important beyond 2020, especially with calls during the 2014 World Parks Congress to ensure at least 30% of MPAs are made no-take zones by 2030.

Addressing actual management effectiveness at a MPA usually requires a survey assessment [51], which has only been completed for a handful of the islands and in most cases only a percentage of the existing protected areas. There are also several methodologies and indicators used for assessing management effectiveness [52]. Due to the lack of information, the various methodologies and the fact that there is no consensus on a common reporting format with common indicators and with agreed upon thresholds that reflect the range of management effectiveness in the Caribbean context, this was not reported. In the future, such common indicators of management effectiveness will be important to map and include towards conservation targets.

4.6. Zoning

A single ubiquitous management objective doesn't necessarily have to cover an entire MPA. An individual MPA can have a zoning plan within its boundaries, where a balance is achieved between comprehensive resource protection and multiple, compatible uses of resources [53,54]. However, the zones within protected area boundaries, such as no-take zones, have not been widely mapped. Due to a lack of spatial data on no-take areas, this is yet to be accurately reported. These too will be important components to add to future analyses for the insular Caribbean.

Zoning does not have to be limited to within a MPA. In fact, along with larger MPA designations, it is also recommended that the insular Caribbean embrace more comprehensive marine spatial planning [55]. Without comprehensive marine spatial planning together with poor comprehensive protected area planning in the marine environment, protection across marine zones can become uneven, usually with the pelagic zone lacking in MPA coverage [38,56]. Lower MPA coverage in the oceanic zone of the insular Caribbean highlights this significant shortcoming in marine conservation. It is recommended that any future marine spatial planning efforts extend to the pelagic zone.

4.7. Marine zone representation

The few MPAs that exist in the oceanic zone of the Caribbean, such as those that seek to protect marine mammals or deep water marine reserves as those observed in Puerto Rico, are useful models for replication with experiences that should be shared with other governments and managers. Remote MPAs do bring with them a set of unique challenges in relation to management, especially for MPA enforcement. With the predominance of nearshore MPAs in the insular Caribbean, the region's MPA managers are perhaps less well-equipped to address the particular challenges of remote MPA management in the oceanic zone. As such, targeted capacity building and sharing of experience could be a fruitful direction for further cooperation.

Our findings about the predominance of nearshore MPAs in the insular Caribbean versus lower MPA coverage in other zones might be perpetuated as an outcome of efforts under the CCI, which has focused largely on the shelf zone. Although sustainable financing measures for MPAs are a top priority for MPA capacity building need in the Caribbean [57], encouraging fee collection from MPA users may also be producing a focus on the establishment of MPAs in more accessible and iconic seascapes of importance to tourism, which has not necessarily provided incentives for equal marine zone representation in marine conservation. As the Caribbean Biodiversity Fund grows and comes into play in helping support effective MPA management in the participating countries and territories, building a greater focus on marine zone representation is recommended into future efforts towards MPA establishment, and applying a proportion of funding generated by MPAs in the shelf zone to help support management of MPAs in the oceanic zone.

4.8. Ecoregions

Based on this current analysis, the extent of protection across the ecoregions of the insular Caribbean can be more confidently reported. The Greater Antilles has more protected areas, but the Eastern Caribbean has a higher MPA coverage thanks to the Agoa Sanctuary. Since the 3 ecoregions of the insular Caribbean are ecologically connected, an uneven protection has implications for conservation effectiveness. The ecoregions in the study area are deserving of a more consistent level of protection, and a greater focus on, and increased support to the countries and territories to better distribute MPA coverage within the Eastern Caribbean and increase MPA coverage in the Bahamian ecoregions is recommended.

4.9. Future research

Beyond mapping no-take zones of MPAs and management effectiveness, an analysis of MPA coverage by habitat types, such as mangroves, sea grass and coral reef, as well coverage of spawning aggregations, aggregations of endangered species, and critical habitat for endangered species (e.g. Important Bird Areas) would be instructive.

There are many benefits of transboundary protected areas [58–60] including a large-scale approach to meet conservation targets [61]. However, in the insular Caribbean, no such intentional transboundary MPAs exist. Beyond the transboundary MPAs that might be easily formed based on pre-existing relationships, further analyses could also include MPA cluster analysis related to connectivity, indicating where transboundary MPAs would be most beneficial overall and possibly assisting with siting MPAs for deeper waters that meet the conservation needs of pelagic biodiversity on the high seas [38,56,62,63].

4.10. Spatial data limitations

Reporting progress and achievement towards MPA targets for a region of small island governments is limited by out-of-date and inaccurate information, and by a lack of tabular information or spatial boundaries. When focusing on protected area representation alone, or as a component of a more robust assessment, any analysis is most useful when it accurately reflects an up-to-date spatial and tabular representation of protected area networks. Marine research and conservation efforts would benefit from a dataset that accurately reflects a changing spatial and tabular representation in near real time, and which could be considered dynamic.

While comprehensive in scope, the WDPA, like any global dataset, is subject to inconsistency propagated by the variety of methods and formats used to create and curate data on protected areas within and between countries. Therefore, to maintain quality and currency over time, the WDPA requires constant updating and validation. As capacity improves at the level of the data provider and better data becomes available, the WDPA in turn also improves, but there is quite often a significant lag time in updating the WDPA once new data becomes available. This in turn leads to significant gaps and inaccuracies in the global database leading to imprecision in analyses that seek to identify conservation gaps and define priorities [10,25,26,64]. While these omissions or inaccuracies in the WDPA originate from the propagation of gaps and inaccuracies in the available spatial data at a point in time, they often persist long after new data becomes available at local scales, rendering the WDPA out of date and inconsistent with some national datasets.

In the past decade, UNEP-WCMC has made great strides in sourcing the best available information, closing data gaps and improving overall quality of the WDPA. By 2015, UNEP-WCMC acquired boundary information for 95% of protected areas recorded in the WDPA, up from only 37% in 2005 and has focused keenly on the improvement of MPA data often entering new MPAs into the WDPA only months or weeks of their establishment or expansion, with the approval of the relevant governments. The WDPA schema also now includes a distinction between completely marine, coastal marine and 'No Take' zones. Should these advances continue MPA focused reports such as this one, as well as those of the recent past [19,26] will no longer see a need to add additional MPA data to the WDPA in order to conduct a representative analysis. Unfortunately, for the Caribbean region, this study still found a difference of 118 polygon records and 200,000 km^2 of MPA coverage between the dataset used in this analysis and the current (January 2015) WDPA. The authors agree with Guarderas [19] that "more effort is needed by each country to provide updated data [to the WDPA]." However, there are still persistent challenges in developing countries for the relevant protected area agencies to map and manage their protected area spatial datasets. This is evident in the Caribbean where agencies are often under-staffed and over-burdened, unable to easily prioritize resources to address outside requests for information [20].

Collaboration between UNEP-WCMC and TNC is underway to ensure the improvements in the insular Caribbean dataset are used to validate and ultimately update the WDPA with official approval of government sources. Maintaining the accuracy of the dataset and continuing to build upon it are challenges that require investment and adequate capacity. While the majority of Caribbean governments have GIS datasets, they often lack the necessary prioritization or resources to update protected area boundaries and attributes. Governments could benefit from strategic partnerships where resources and talent can be shared to fill the technical and resource capacity gaps where they exist. Using a regional approach via partner collaboration, national expert review and validation to sustain the protected area dataset is recommended. This process could facilitate regular updates to the WDPA and thus ensure timely data flows and greater consistency in representations of the insular Caribbean protected area dataset, in turn helping to sustain its usage.

5. Conclusions

In the insular Caribbean, MPAs are a critical instrument within a suite of many on which regional conservation strategies are built. An accurate and current inventory of MPAs is critical in assessing progress towards targets, especially given the dynamic nature of protected area datasets. The insular Caribbean protected area dataset used in this study represents the most accurate baseline to date on which country-level, ecoregion and marine zone MPA statistics can be reported. From the analyses in this study it is concluded that MPA coverage in the insular Caribbean is close when compared with global figures and not as far below global and regional targets as others have reported.

Although regionally, the insular Caribbean could achieve 10% MPA coverage with another large marine mammal sanctuary, the rate of MPA establishment to date among most of the individual governments brings into question the feasibility of achieving all CBD and CCI targets before 2020. The CCI, along with similar regional initiatives, are vital to help increase political will and to help foster the enabling environments needed to produce continued MPA expansion and strengthening. For such initiatives to have greatest impact, this article highlights possible directions for support of marine conservation in the insular Caribbean such as increasing the size of MPAs; a greater focus on marine zone representation in MPA establishment, especially increasing the focus on the establishment of MPAs in the oceanic zone (with associated sharing of experiences, management capacity building and financing tailored to support more remote MPAs); increased support to the countries and territories of the Eastern Caribbean and Bahamian ecoregions in the designation of new MPAs; and greater focus on the establishment of MPAs in IUCN Category I (a) to increase no-take zones, and VI to address sustainable use and management of marine and coastal resources. Importantly, effective protection requires the existence of regional and sub-regional networks of MPAs that promote meaningful collaboration across international boundaries in order to build capacity for MPA management and to share best practices.

There were significant improvements in the WDPA for the Caribbean subsequent to this analysis, following on the 2014 United Nations List of Protected Areas publication, but there are still many discrepancies. To ensure consistency going forward, TNC will continue to coordinate with UNEP-WCMC so that the global

and regional datasets are aligned. As efforts to fulfill commitments to regional and global biodiversity goals continue to gain momentum, accessible, viewable and accurate datasets serve as important resources to Caribbean governments and entities seeking to assess current levels of marine protection and to prioritize remaining gaps in conservation.

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References

[1] Burke L, Reytar K, Spalding M, Perry A. Reefs at risk revisited. . World Resources Institute; 2011.
[2] Jackson JB. Reefs since Columbus. Coral Reefs 1997;16:S23–32.
[3] Spalding M, Kainuma M, Collins L. World atlas of mangroves. Earthscan; 2010.
[4] Mora C. A clear human footprint in the coral reefs of the Caribbean. Proc R Soc B Biol Sci 2008;275:767–73.
[5] Halpern BS. The impact of marine reserves: do reserves work and does reserve size matter? Ecol Appl 2003;13:117–37.
[6] Wilkinson C, Salvat B. Coastal resource degradation in the tropics: does the tragedy of the commons apply for coral reefs, mangrove forests and seagrass beds. Mar Pollut Bull 2012;64:1096–105.
[7] x+ Guidelines for applying protected area management categories. In: Dudley N, editor. Gland, Switzerland: IUCN; 2008. p. 86.
[8] Kelleher G, Kenchington R. Guidelines for establishing marine protected areas. Gland, Switzerland: IUCN; 1992. p. 79 IUCN.
[9] Secretariat of the Convention on Biological Diversity.Global biodiversity outlook 3. Montréal; 2010. 94 p.
[10] Wood LJ, Fish L, Laughren J, Pauly D. Assessing progress towards global marine protection targets: shortfalls in information and action. Oryx 2008;42:340–51.
[11] Butchart SHM, et al. Global biodiversity: indicators of recent declines. Science 2010;328:1164–8.
[12] The Millennium Development Goals Report. 67. United Nations, at ⟨http://www.un.org/millenniumgoals/pdf/(2011_E)%20MDG%20Report%202011_Book%20LR.pdf⟩; 2011.
[13] The Millennium Development Goals Report 2013. 68. United Nations, at ⟨http://www.un.org/millenniumgoals/pdf/report-2013/mdg-report-2013-english.pdf⟩; 2013.
[14] Bertzky B, et al. Tracking progress towards global targets for protected areas. Protected planet report 2012. Cambridge, UK: IUCN, Gland, Switzerland and UNEP-WCMC; 2012.
[15] Juffe-Bignoli D, et al. Protected planet report 2014. Cambridge, UK: UNEP-WCMC; 2014.
[16] Deguignet M, et al. United Nations list of protected areas. Cambridge, UK: UNEP-WCMC; 2014Cambridge, UK: UNEP-WCMC; 2014.
[17] Butchart SHM, et al. Shortfalls and solutions for meeting national and global conservation area targets. Conserv Lett 2015. http://dx.doi.org/10.1111/conl.12158.
[18] Milligan HD, Deinet S, McRae L, Freeman R. Protecting species: status and trends of the earth's protected areas. Preliminary report. 23. Zoological Society of London; 2014.
[19] Guarderas AP, Hacker SD, Lubchenco J. Current status of marine protected areas in Latin America and the Caribbean. Conserv Biol 2008;22:1630–40.
[20] Appeldoorn RS, Lindeman KC. A Caribbean-wide survey of marine reserves: spatial coverage and attributes of effectiveness. Gulf Caribbean Res 2003;14(2):139–54.
[21] UNEP [United Nations Environmental Programme]. COP 10 Decision X/2. Strategic plan for biodiversity 2011–2020. Further information related to technical rationale for Aichi Biodiversity Targets, including potential indicators and milestones. UNEP/CBD/COP/10/INF/12/Rev.1. UNEP, Nagoya, Japan; 2011.
[22] CBD. COP Decision X/2. Strategic plan for biodiversity 2011–2020, available at: ⟨http://www.cbd.int/decision/cop/?id=12268⟩; (2010) [accessed 1 October 2013].
[23] Caribbean Challenge Initiative. At ⟨http://www.caribbeanchallengeinitiative.org/⟩; 2014.
[24] The World Database on Protected Areas (WDPA). At ⟨http://www.protectedplanet.net⟩; 2011.
[25] Chape S, Harrison J, Spalding M, Lysenko I. Measuring the extent and effectiveness of protected areas as an indicator for meeting global biodiversity targets. Philos Trans R Soc B Biol Sci 2005;360:443–55.
[26] Spalding MD, Meliane I, Milam A, Fitzgerald C, Hale LZ. Ocean yearbook 27. In: Chircop M, Coffen-Smout S, McConnell M, editors. Martinus Nijhoff; 2013. p. 213–48. ⟨http://www.cbd.int/doc/meetings/mar/cbwsoi-seasi-01/other/cbwsoi-seasi-01-protecting-marine-spaces-en.pdf⟩.
[27] OAS (Organization of American States). Inventory of Caribbean marine and coastal protected areas. Washington, DC: Organization of American States; 1988. p. 146.
[28] Huggins AE, et al. Biodiversity conservation assessment of the insular Caribbean using the Caribbean decision support system. Technical report. The Nature Conservancy; 2007.
[29] Prototype Global Shoreline Data. At ⟨http://dnc.nga.mil/NGAPortal/DNC.portal?_nfpb=true&_pageLabel=dnc_portal_page_72⟩; 2014.
[30] General Bathymetric Chart of the Oceans. At ⟨www.gebco.net⟩; 2008.
[31] Sullivan Sealey K, Bustamante G. Setting geographic priorities for marine conservation in Latin America and the Caribbean. The Nature Conservancy; 1999.
[32] Lourie SA, ACJ. Vincent. Using biogeography to help set priorities in marine conservation. Conserv Biol 2004;18:1004–20.
[33] Spalding MD, et al. Marine ecoregions of the world: a bioregionalization of coastal and shelf areas. BioScience 2007;57:573–83.
[34] United Nations Convention on the Law of the Sea. At ⟨http://www.un.org⟩; 1982.
[35] Tyler PA. Ecosystems of the deep oceans. Elsevier Science; 2003.
[36] FGDC (Federal Geographic Data Committee). FGDC-STD-018-2012. Coastal and marine ecological classification standard. Reston, VA: Federal Geographic Data Committee; 2012.
[37] Ward N, Dominquez Tejo E. Our humpback whales, protection beyond borders. Editora Centenario; 2014.
[38] Game ET, et al. Pelagic protected areas: the missing dimension in ocean conservation. Trends Ecol Evol 2009;24:360–9.
[39] Toonen RJ, et al. One size does not fit all: the emerging frontier in large-scale marine conservation. Mar Pollut Bull 2013;77:7–10.
[40] Edgar GJ, et al. Global conservation outcomes depend on marine protected areas with five key features. Nature 2014;506:216–20.
[41] Jonas HD, Lucas S. Legal aspects of the Aichi biodiversity target 11: a scoping paper. Rome: International Development Law Organization; 2013.
[42] De Santo EM. Missing marine protected area (MPA) targets: how the push for quantity over quality undermines sustainability and social justice. J Environ Manage 2013;124:137–46.
[43] Davey AG. National system planning for protected areas. Gland, Switzerland and Cambridge, UK: IUCN; 1998. p. 71 x+.
[44] Bishop K, Dudley N, Phillips A, Stolton S. Speaking a common language: the uses and performance of the IUCN system of management categories for protected areas. IUCN—The World Conservation Union, UNEP World Conservation Monitoring Centre and Cardiff University; 2004.
[45] Dahlgren C. Review of the benefits of no-take zones. A report to the Wildlife Conservation Society. vol. 104. Wildlife Conservation Society; 2014.
[46] Dalton T, Forrester G, Pollnac R. Are Caribbean MPAs making progress toward their goals and objectives? Mar Policy 2015;54:69–76.
[47] Garces LR, Pido MD, Tupper MH, Silvestre GT. Evaluating the management effectiveness of three marine protected areas in the Calamianes Islands, Palawan Province, Philippines: process, selected results and their implications for planning and management. Ocean Coast Manage 2013;81:49–57.
[48] Soma K, et al. The 'mapping out' approach: effectiveness of marine spatial management options in European coastal waters. ICES J Mar Sci/J Cons 2013. http://dx.doi.org/10.1093/icesjms/fst193.
[49] White AT, et al. Marine protected areas in the coral triangle: progress, issues, and options. Coast Manage 2014;42:87–106.
[50] Day J, et al. Guidelines for applying the IUCN protected area management categories to marine protected areas. Gland, Switzerland: IUCN; 2012.
[51] Hockings M, Stolton S, Leverington F, Dudley N, Courrau J. Evaluating effectiveness: a framework for assessing management effectiveness of protected areas. 2nd ed. Gland, Switzerland and Cambridge, UK: IUCN; 2006. p. 105 xiv+.
[52] Leverington F, et al. Management effectiveness evaluation in protected areas—a global study. 2nd ed. Australia: The University of Queensland; 2010.
[53] Agardy T. Information needs for marine protected areas: scientific and societal. Bull Mar Sci 2000;66:875–88.
[54] Villa F, Tunesi L, Agardy T. Zoning marine protected areas through spatial multiple-criteria analysis: the case of the Asinara Island National Marine Reserve of Italy. Conserv Biol 2002;16:515–26.
[55] Agardy T, di Sciara GN, Christie P. Mind the gap: addressing the shortcomings of marine protected areas through large scale marine spatial planning. Mar Policy 2011;35:226–32.

[56] Jobstvogt N, Hanley N, Hynes S, Kenter J, Witte U. Twenty thousand sterling under the sea: estimating the value of protecting deep-sea biodiversity. Ecol Econ 2014;97:10–9.
[57] Gombos M, et al. A management capacity assessment of selected coral reef marine protected areas in the Caribbean. 269 (the National Oceanic and Atmospheric Administration (NOAA) Coral Reef Conservation Program (CRCP), the Gulf and Caribbean Fisheries Institute (GCFI) and by the UNEP—CEP Caribbean Marine Protected Area Management Network and Forum (CaMPAM)), at ⟨http://campam.gcfi.org/CapAssess/CaMPAMCapacityAssessment2011.pdf⟩; 2011.
[58] Ervin J, Sekhran A, Dinu A, Gidda S, Vergeichik M, Mee J. Protected areas for the 21st century: lessons from UNDP/GEF's portfolio. New York and Montreal: United Nations Development Programme and Convention on Biological Diversity; 2010.
[59] Sandwith T, Shine C, Hamilton L, Sheppard D. Transboundary protected areas for peace and co-operation. Gland, Switzerland and Cambridge, UK: IUCN; 2001. p. 111 xi+.
[60] MacKinnon K. Transboundary reserves—World Bank implementation of the ecosystem approach, vol. 11. World Bank; 2000. ⟨http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2000/10/21/000094946_00101105374277/Rendered/PDF/multi_page.pdf⟩ at.
[61] Guerreiro J, et al. Establishing a transboundary network of marine protected areas: diplomatic and management options for the east African context. Mar Policy 2010;34:896–910.
[62] Schill S, Raber G, Roberts J, Treml E. A vision for protecting marine resources across the Caribbean biological corridor. The Nature Conservancy; 2012.
[63] Barbier EB, et al. Protect the deep sea. Nature 2014;505:475–7.
[64] Visconti P, et al. Effects of errors and gaps in spatial data sets on assessment of conservation progress: errors and gaps in spatial data sets. Conserv Biol 2013. http://dx.doi.org/10.1111/cobi.12095.