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An Ecological Coherence Assessment of the Wider Caribbean Region MPA Network

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MESPOM

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No portion of the work referred to in this thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

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ABSTRACT OF THESIS submitted by:
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Marine protected areas (MPAs) are an area-based management tool that serve as the cornerstone for marine conservation. There has been a recent shift from establishing MPAs on an *ad hoc* basis to establishing MPA networks, partly driven by Aichi Biodiversity Target 11, which called for 10% coastal and marine coverage by 2020. Ecological coherence assessments can help determine if a group of individually established MPAs can retroactively be considered ecologically coherent, or if an intentionally established MPA network is ecologically coherent. This research, focusing on the Wider Caribbean Region, provides the first ecological coherence assessment of an MPA network outside of European waters. The ecological coherence of the Wider Caribbean Region MPA network was assessed by running fourteen tests to measure four main criteria: representativity, replicability, connectivity, and adequacy. Novel methodologies were presented for two of these tests: the human impact test and the ecologically important areas test. The results of the tests were aggregated using a methodology that incorporated uncertainty in the methods, data, and targets. The results showed that the network was likely to have achieved ecological coherence in terms of representativity, unlikely to have achieved ecological coherence in terms of replicability and connectivity, and very unlikely to have achieved ecological coherence in terms of adequacy. To get closer to ecological coherence, the region should focus on increasing no-take MPAs or zones and increasing the number of large MPAs. Overall, this assessment concluded that the Wider Caribbean Network is *very unlikely* to have achieved ecological coherence.

Keywords: Ecological coherence, MPA, marine, spatial analysis, GIS, conservation, protected areas, Caribbean

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List of Abbreviations

ABNJ	Area Beyond National Jurisdiction
AZE	Alliance for Zero Extinction
CaMPAN	Caribbean MPA Managers Network
CBD	Convention on Biological Diversity
CEP	Caribbean Environment Programme
EBSA	Ecologically and Biologically Significant Area(s)
EEZ	Exclusive Economic Zone
EUNIS	European Nature Information System
HELCOM	Helsinki Commission
IBA	Important Bird Area(s)
IUCN	International Union for Conservation of Nature
KBA	Key Biodiversity Area(s)
MedPAN	Mediterranean Protected Areas Network
MiCO	Migratory Connectivity in the Ocean
MPA	Marine Protected Area
NOAA	National Oceanic and Atmospheric Administration
OECM	Other effective area-based conservation measures
OSPAR	Oslo/Paris Convention (for the Protection of the Marine Environment of the North-East Atlantic)
PAME	Protected Area Management Effectiveness
SIDS	Small island developing states
SPA/RAC	Regional Activity Center for Specially Protected Areas
SPAW	Specially Protected Areas and Wildlife
UNCLOS	United Nations Conference on the Law of the Sea
UNEP	United Nations Environment Programme
UNESCO	The United Nations Educational, Scientific and Cultural Organization
WCMC	World Conservation Monitoring Centre
WCPA	World Commission on Protected Areas
WDPA	World Database on Protected Areas
WVS	World vector shoreline

Chapter 1: Introduction

1.1 General Introduction

For centuries, people believed that the ocean was immune to damage from humans. This is not the case. Anthropogenic activities, both on land and sea, result in pressures that negatively impact marine ecosystems and can result in ecosystem destruction and collapse (Scheffer et al. 2001). In the Wider Caribbean Region, the study area of this research, the marine environment is threatened by coastal development, overfishing, sedimentation and pollution, climate change, and disease (Burke and Maidens 2004; FAO 2014). In the Caribbean, marine resources are especially important, as they are essential for human well-being (Chakalall et al. 2007). Marine protection is crucial to protect fish stocks, as well as to conserve biodiversity and other resources, and preserve cultural values (Bustamante and Vanzella-Kouri, 2011).

To reduce the impact of anthropogenic pressures on marine ecosystems, various conservation techniques are employed, with the cornerstone of marine conservation being marine protected areas (MPAs) (Giakoumi et al. 2018). MPAs are an area-based management tool that can provide significant ecological, economic, and social benefits (Giakoumi et al. 2018). The movement to establish MPAs began in the 1960s, with MPA coverage increasing drastically in recent decades. This recent drive to establish MPAs and more specifically, MPA networks, has been partly spurred by global marine conservation goals, particularly Aichi Biodiversity Target 11. This target states that, "by 2020, at least 17 percent of terrestrial and inland water, and 10 percent 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" (CBD COP 2010).

The goal of MPA networks is to reach ecological coherence. An ecologically coherent MPA network is one that interacts with and supports the wider environment; maintains the processes, functions, and structures of the intended protected features across their natural range; and functions synergistically as a whole, such that the individual protected sites benefit from each other to achieve the other two objectives (Ardron 2008a; Ardron 2008b; OSPAR 2007). Ecological coherence assessments can help determine if a group of individually established MPAs can retroactively be considered ecologically coherent, to determine if an intentionally established MPA network is ecologically coherent, and to help plan future MPA networks to ensure their likelihood of being ecologically coherent.

To assess ecological coherence, several criteria that describe the network are measured. In general, four main criteria are measured: representativity, replicability, connectivity, and adequacy:

- *Representativity*: whether the MPA network captures the full range of ecosystems in the region
- *Replicability*: the network has multiple sites with a given feature
- *Connectivity*: individual sites benefit each other through species exchanges and functional linkages
- *Adequacy*: sites are of sufficient size and protection status to safeguard the features they are meant to protect.

Evaluative tests are run within each of the four main criteria, and the results of each test are compared against a scientifically established threshold. The more thresholds that are met, the more likely that ecological coherence has been met. To date, not a single MPA network has been deemed to be ecologically coherent (Rees et al. 2018).

This ecological coherence assessment was conducted in the Wider Caribbean Region. To date, ecological coherence assessments have only been conducted in European waters, so this assessment is unique by testing a methodology in an area where it has not been applied. The Caribbean was chosen because very few studies have looked at the status of MPAs in the region as whole, so this will give a much-needed overview of the protected area network. The Caribbean has many MPAs, but there is no evidence of a concerted, unified effort to develop a region-wide ecologically coherent network of MPAs. This assessment will serve as a baseline to determine if the more-or-less *ad hoc* creation of MPAs may retroactively be considered an ecologically coherent network.

This ecological coherence assessment of the Wider Caribbean Region consists of a total of 14 tests. There are four tests for representativity, four tests for replicability, three tests for connectivity, and three tests for adequacy. These tests were run in ArcGIS Pro and Excel. The results of the tests were aggregated using a technique developed by Wolters et al. (2015) and used in the most recent Helsinki Commission (HELCOM) ecological coherence assessment of the Baltic Sea (HELCOM 2016). This aggregation methodology uses a one-out-all-out principle that results in a final score of the likelihood of the MPA network having reached ecological coherence.

The results showed that representativity was ***likely*** to have achieved ecological coherence, replicability and connectivity were ***unlikely*** to have achieved ecological coherence, and adequacy was ***very unlikely*** to have achieved ecological coherence. Overall, this assessment concluded that the Wider Caribbean Network is ***very unlikely*** to be ecologically coherent. The results highlight major gaps in the network and this information can be used to improve marine protection and bring the region closer to ecological coherence.

1.2 Aim and Objectives

The aim of this research was to assess the ecological coherence of the Wider Caribbean Region MPA network. To achieve that aim, the research:

1. Assessed the representativity of the Caribbean MPA network.
2. Assessed the replicability of the Caribbean MPA network.
3. Assessed the connectivity of the Caribbean MPA network.
4. Assessed the adequacy of the Caribbean MPA network.
5. Aggregated the results of the four criteria into a single metric of ecological coherence that incorporates uncertainty it the data, methods, and targets.
6. Determined gaps in the MPA network and compared the ecological coherence of the Wider Caribbean Region MPA network to other MPA networks that have been assessed for ecological coherence.

1.3 Scope

The study area for this assessment is the Wider Caribbean Region (Figure 1). The study area extends to Florida in the north, French Guiana in the south, and is bounded by the exclusive economic zones (EEZ) of all the countries and territories within the region, i.e., zones which extend 200 nautical miles from shore. The study area also contains the two patches of Areas Beyond National Jurisdiction (ABNJ) in the Gulf of Mexico. The region was divided into nine subregions, as defined by Burke and Maidens (2004).

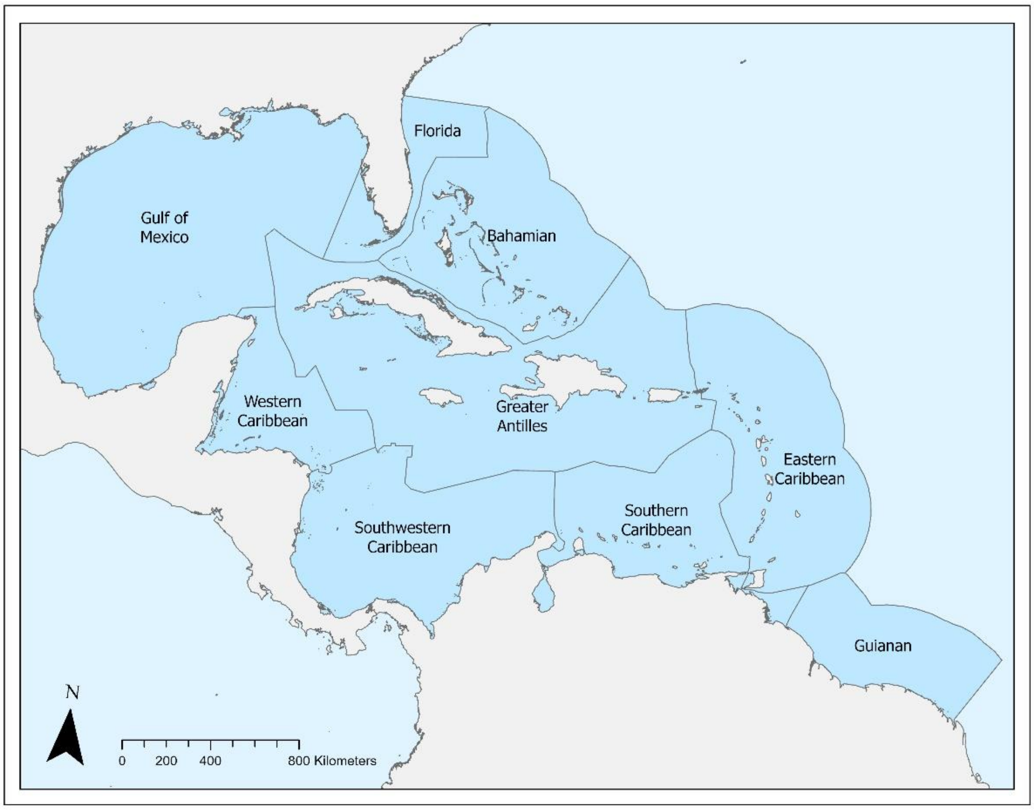

Figure 1. The Wider Caribbean Region, divided into nine subregions, as per Burke and Maidens (2004). Data sources: Flanders Marine Institute (2019); NOAA (2017); Burke and Maidens (2004).

The assessment conducted here is an ecological coherence assessment, which is a measurement of the biological and network considerations of the MPA network. This is not an overall assessment of MPA effectiveness because it does not include other important considerations of an MPA network, such as management effectiveness. MPA management is particularly poor in the Caribbean, where only a small proportion of MPAs are well managed (Appeldoorn and Lindeman 2003; Burke and Maidens 2004), but that is beyond the scope of this assessment.

1.4 Overview

Chapter 1 provides background information about marine protection, MPAs, ecological coherence, and the Caribbean marine environment. This chapter also outlines the aims and objectives of the research, as well as the physical and theoretical scope of the research.

Chapter 2 is a literature review of previous ecological coherence assessments. It also presents a short history of MPAs and MPA networks, discusses the concept of ecological coherence and how it is measured, and provides detail on the study area. **Chapter 3** describes the research methodology. First, the data preparation process for the study area data, MPA data, habitat data, and biogeographic zone data is explained. Next, each of the fourteen ecological coherence tests are described. A short explanation of each test and its corresponding threshold is given, as well as detailed steps for running the analysis of each test. Finally, the methodology for how the results will be aggregated is described. **Chapter 4** is divided into subchapters for each of the four main criteria. Within each main criterion, the test results are summarized, including graphs and figures. There is also a subchapter dedicated to aggregating the criteria, and the final ecological coherence score is declared. **Chapter 5** discusses the wider implications of the results. Geographic differences within the Wider Caribbean Region are analyzed, and the status of the MPA network in the study area is compared to other MPA networks. This chapter also discusses the data gaps and limitations, reflects on the target setting process, and scrutinizes the methodology. **Chapter 6** provides a summary of the research and conclusions.

Chapter 2: Literature review

2.1 Importance of Marine Protection

The ocean is essential for life on Earth, including humans. The ocean produces over the half the world's oxygen, is responsible for climate regulation, facilitates transportation, and provides medicinal products, livelihoods for millions of people, transportation, recreation opportunities, and 17% of the current production of edible meat (Costello et al. 2020; NOAA 2021). However, anthropogenic activities, both on land and sea, result in pressures that negatively impact marine ecosystems. These anthropogenic activities include climate change, physical disturbance (e.g. fishing), inputs to the ocean (e.g. toxic substances), alteration of ocean space and coastal areas, noise, interference with migration, and introducing non-native species (Boldt et al. 2014; UN 2016). Any of these pressures alone can have severe negative impacts on marine ecosystems, however many are the result of cumulative impacts of multiple pressures from multiple drivers (UN 2016), and can result in ecosystem destruction and collapse (Scheffer et al. 2001). For example, lower oxygen levels or higher temperatures caused by various human activities can reduce species resilience, which would further hinder that species' ability to recover from another human activity such as an oil spill (UN 2016).

Anthropogenic activities not only damage marine environments, but also trigger negative social and economic ramifications. While many marine anthropogenic activities are aimed to benefit humans socially or economically, they often end up having the opposite effect. For example, fishing, which aims to provide social and economic benefits through food and employment, can have negative long-term social and economic impacts if an area is overfished and fish stocks are depleted (UN 2016). To reduce the impact of anthropogenic pressures on marine ecosystems, various conservation techniques are employed, with the cornerstone of marine conservation being MPAs (Giakoumi et al. 2018).

2.2 MPA Definition and Background

According to the International Union for Conservation of Nature (IUCN) (2012), "a protected area is 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". To be considered an MPA, a marine area must meet this definition.

The first World Conference on National Parks in 1962, which encouraged governments to "examine as a matter of urgency the possibility of creating marine parks or reserves" (Adams 1962), marked the beginning of the movement to establish MPAs. However, there were already some marine areas protected before then, with the first MPA established in Florida around 1935. Organizations and governments around the world were showing interest in marine conservation and establishing MPAs (Bjorklund 1974) and by 1970 there were 118 MPAs in 27 countries (Silva et al. 1986).

According to Humphreys and Clark (2020), another global driver to create MPAs was the third United Nations Conference on the Law of the Sea (UNCLOS) from 1976-1982, as UNCLOS officially extended national maritime jurisdictions from three to 200 nautical miles, henceforth known as a nation's "Exclusive Economic Zone" (EEZ). Along with giving nations exclusive rights to marine resources within their EEZ, it was also an incentive to protect such resources. Thus, UNCLOS provided a shift in marine conservation framework and brought forward the idea that terrestrial protection designations could similarly be applied to marine environments (Humphreys and Clark 2020). UNCLOS, along with several other international policies established around the same time, contributed to the continued expansion of MPAs worldwide and the establishment of MPAs as a global marine conservation strategy. By 1985 there were 430 MPAs in 69 countries (Silva et al. 1986). During the 1990s science became more influential in the decision-making and management process of MPAs and the number of MPAs continued to increase (Wells et al. 2016).

Global targets became a focus in the 2000s, with several international agreements on global marine protection setting target coverage for conserved marine areas. One of the more recent targets in marine conservation is Aichi Target 11, part of the Convention on Biological Diversity's (CBD) Strategic Plan for Biodiversity 2011-2020. This target was set in 2010 and states that, "by 2020, at least 17 percent of terrestrial and inland water, and 10 percent 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" (CBD COP 2010). The target was not reached by 2020. As of 2021, 7.74% of the ocean is covered by 18,584 MPAs (UNEP-WCMC & IUCN 2021b).

To replace this recently expired Strategic Plan for Biodiversity, the CBD is in the midst of developing a post-2020 Global Biodiversity Framework. The zero draft text proposal of this framework includes a more ambitious 30% marine protection target for 2030 (CBD 2020). This target states that, "by 2030, protect and conserve through well connected and effective system of protected areas and other effective area-based conservation measures at least 30 percent of the planet with the focus on areas particularly important for biodiversity." (CBD 2020).

2.3 Benefits and Challenges of MPAs as an Effective Conservation Tool

MPAs are one example of an area-based management tool. MPAs are seen as the cornerstone of marine conservation (Giakoumi et al. 2018), with the importance of other effective area-based conservation measures (OECM) only recently beginning to be recognized (Maxwell et al. 2020). OECMs are a new conservation approach, in which conservation is achieved in an area as a by-product of management. The main different between OECMs and protected areas (e.g. MPAs) is that biodiversity must be the primary objective of protected areas, whereas OECMs must provide biodiversity conservation, regardless of its primary objective (Alves-Pinto et al. 2021). MPAs can provide significant ecological, economic, and social benefits and are the main tool for promoting long-term marine conservation (Giakoumi et al. 2018). When MPAs are completely protected, well-enforced and of appropriate size, they are excellent tools for protecting biodiversity and marine life abundance (PISCO & UNS 2016). However, this is not always the case. MPAs can fail to conserve marine ecosystems for a number of reasons, such as poor management and enforcement, low levels of protection, and poor design.

Many MPAs around the world are "paper parks", which are areas that are de jure designated as protected but are not actually providing protection de facto. This is often due to poor planning, poor management, low enforcement or surveillance, lack of stakeholder engagement, and conflicting political interests (Giakoumi et al. 2018; Pieraccini et al. 2016). Another factor contributing to the number of "paper park" MPAs is the rush to achieve global area-based targets, such as the Aichi Target 11. According to Carr et al. (2020), recent progress in MPAs seems to be less focused on the qualitative aspect of Aichi Target 11 (i.e. *effective* MPAs) and more on achieving just the quantitative measure.

Another obstacle for MPA effectiveness is low levels of protection. In general, protection offered by MPAs is very weak and the standard for what counts as a protected area is very low (Sala et al. 2018). For instance, many MPAs offer protection to only a single species or prohibit only a single specific activity (Sala et al. 2018). Many MPAs permit extractive activities such as destructive fishing practices, which degrade, rather than improve, biodiversity (Sala et al. 2018). A study by Costello and Ballantine (2015) found that 94% of MPAs allow fishing and less than 1% of the ocean is designated as no-take.

MPA coverage has increased dramatically in recent decades, with global MPA coverage increasing more than fivefold from 2005 to 2020 (UNEP-WCMC & IUCN 2021b). However, the global MPA network is unevenly distributed and generally lacks sufficient protection (UNEP-WCMC & IUCN 2021b). This progress in expanding coverage has, in large part, been achieved by establishing large scale MPAs. The 20 largest MPAs account for more than 60% of worldwide MPA coverage (UNEP-WCMC 2020), indicating that marine protection is concentrated in a few areas. The uneven distribution of MPAs between national waters and the areas beyond national jurisdiction (ABNJ; high seas) is also important to note. ABNJ constitutes up to 61% of the global ocean, but only 1.18% is protected by MPAs (UNEP-WCMC & IUCN 2021c).

2.4 The Evolution of MPA Networks

Aichi Target 11 calls for MPA networks, or “well-connected systems”, not just pure coverage. This target is evidence that marine conservation strategies are moving beyond individual MPAs. This network approach to MPA design and planning is a recent trend in marine conservation, whereas previous MPAs were largely established on an *ad hoc* basis.

More than just a collection of MPAs in a geographic region, an MPA network is defined by IUCN as “a collection of individual MPAs operating cooperatively and synergistically at various spatial scales and with a range of protection levels that are designed to meet objectives that a single reserve cannot achieve” (WCPA/IUCN 2007). An MPA network should have greater social, ecological, and economic benefits than its individual parts. An MPA network should be coordinated, such that the system is linked administratively, as well as ecologically.

MPA networks can be beneficial ecologically, socially, and economically (IUCN-WCPA 2008). Ecologically, an MPA network can promote healthy marine ecosystems by protecting more mobile species, protecting large-scale processes, reducing multiple anthropogenic impacts, improving resilience by spreading the risk of local disasters, and mitigating the risk of climate change (IUCN-WCPA 2008). Socially, a network of MPAs can help manage conflicts relating to the use of natural resources (IUCN-WCPA 2008). Economically, an MPA network is more practical than one large MPA, as it can promote cost sharing and long-term sustainable fisheries (IUCN-WCPA 2008).

MPA networks should also contain social networks that bring together scientists, practitioners, and policy makers from the individual MPAs to promote the holistic systems approach. During the 2000s “social and learning” networks of MPAs were established in various regions to bring together stakeholders and communities to share their advice and experiences (Wells et al. 2016). For example, The Caribbean MPA Managers Network (CaMPAN), the North America Marine Protected Area Network (NAMPAM) and the Mediterranean Protected Area Network (MedPAN) were formed.

2.5 Ecological Coherence of MPA Networks

The recent drive to establish MPA networks has made it necessary to determine whether existing MPAs that had been created on an *ad hoc* basis can retrospectively be considered together as “ecologically coherent” networks. Ecological coherence is the overall goal of the design and assessment of MPA networks. There is no single agreed upon definition of ecological coherence and the term is rarely used in scientific literature (Ardron 2008a). Rather, it is more of a policy-driven concept. Ecological coherence is a legal term, with origins linked to the Habitats Directive (92/43/EEC; EC 1992) in 1992 which, together with the Birds Directive, established Natura 2000 (Catchpole 2012). Ecological coherence was later used in an international policy-context when it was adopted by the OSPAR Commission in 2006 (Catchpole 2012).

Despite the lack of a clear definition, the overall characteristics that make up an ecologically coherent MPA system, as determined by Laffoley et al. (2006) and OSPAR (2006) and synthesized by Ardron (2008a; 2008b) and OSPAR (2007), are generally agreed upon. According to them, an ecologically coherent MPA network is one that:

i. interacts with and supports the wider environment;
ii. maintains the processes, functions, and structures of the intended protected features across their natural range;
iii. functions synergistically as a whole, such that the individual protected sites benefit from each other to achieve the other two objectives.

Additionally, an ecologically coherent network of MPAs may:

iv. be designed to be resilient to changing conditions.

2.6 Measuring Ecological Coherence

To assess ecological coherence, criteria that describe the network are chosen and measured. These criteria describe different characteristics of the MPA network such as size, location, shape, and spacing. Although there is no "official" set of criteria that make up ecological coherence, most assessments measure ecological coherence according to four criteria: representativity, replication, connectivity, and adequacy (Table 1; OSPAR 2007; HELCOM 2010; Wolters et al. 2015; MedPAN & SPA/RAC 2019). These four criteria are also defined by the CBD Decision IX/20 (CBD 2008). While these criteria were defined by the CBD as criteria for *designing* MPA networks, they are also useful for *assessing* MPA networks and determining if MPA networks meet the standards established by the CBD. For a network to be considered ecologically coherent, all four criteria must meet a set minimum standard. Although the major ecological coherence assessments have focused on just these four criteria, other literature has highlighted the importance of other criteria. For example, WCPA/IUCN (2007) adds resilience and permanence, and OSPAR (2013) mentions protection level.

Table 1. Criteria used to assess ecological coherence in MPA networks.

MPA network	**Criteria assessed for ecological coherence**	**Notes**
OSPAR (OSPAR 2013)	• Representativity • Replication • Connectivity • Adequacy/viability	

HELCOM (HELCOM 2010; 2016)	• Representativity • Replication • Connectivity • Adequacy	
California (Saarman et al. 2013)	• Representation • Replication • Spacing (similar to connectivity) • Size (similar to adequacy)	These were design principles used, not ecological coherence assessment criteria.
California Channel Islands (Airamé et al. 2003)	• Percentage in MPAs • Representation • Vulnerable habitats • Species of special concern and critical life-history stages • Exploitable species • Ecosystem functioning and linkages • Ecosystem services • Human threats and natural catastrophes • Size and connectivity	These were design principles used, not ecological coherence assessment criteria.
Celtic Seas (Foster et al. 2017)	• Representativity • Replication • Connectivity • Adequacy • Viability	
European Commission (Wolters et al. 2015)	• Representativity • Replication • Connectivity • Adequacy	
Mediterranean (MedPAN & SPA/RAC 2019)	• Representativity • Replication • Connectivity • Adequacy	
Canada (Smith et al. 2009)	• Representativity • Replicated ecological features • Connectivity • Adequate and viable sites • Ecologically or biologically significant areas	These were design principles used, not ecological coherence assessment criteria.

2.6.1 Representativity

A representative MPA network captures the full range of ecosystems in the region. According to CBD (2008), "representativity is captured in a network when it consists of areas representing the different biogeographical subdivisions of the global oceans and regional seas that reasonably reflect the full range of ecosystems, including the biotic and habitat diversity of those marine ecosystems." Examples include, "A full range of examples across a biogeographic habitat, or community classification; relative health of species and communities; relative intactness of habitat(s); naturalness" (CBD 2008).

Representativity assessments consider different types of areal coverage to ensure that different features (e.g. species), or factors associated with features (e.g. suitable habitat), are contained within the network. The most basic representativity test is a basic coverage test, which measures overall MPA coverage in the region and/or subregions. Representativity is also assessed for the coverage of other conservation features including biogeographic zones, habitats, depth classes, species, or ecologically significant areas.

2.6.2 Replication

Replication in an MPA network means the network has multiple sites with a given feature. According to CBD (2008), "replication of ecological features means that more than one site shall contain examples of a given feature in the given biogeographic area. The term 'features' means 'species, habitats and ecological processes' that naturally occur in the given biogeographic area" (CBD 2008).

Replication was compared to insurance by HELCOM (2016) – it is important in case something happens to a subset of reserves in the network. For instance, if management failures and anthropogenic pressures cause an MPA to fail in its conservation objectives or a natural disaster destroys the features, replicate features will be protected in other MPAs. Ideally, replicates should be spread out throughout the region to reduce the probability of multiple MPAs being lost from the single event (Appeldoorn and Lindeman 2003). But replicates should also be close enough that a nearby MPA could repopulate a damaged MPA (Appeldoorn and Lindeman 2003). Replicated features may also increase connectivity by acting as stepping stones for dispersing marine species (Sciberras et al. 2013).

Assessing replication consists of counting the number of replicates of a given feature within the MPA network and/or subset of the network. The features that are most commonly assessed for replicability in ecological coherence assessments are habitats, biogeographic zones, and/or species.

2.6.3 Connectivity

In a connected MPA network, individual sites benefit each other through species exchanges and functional linkages. According to CBD (2008), "Connectivity in the design of a network allows for linkages whereby protected sites benefit from larval and/or species exchanges, and functional linkages from other network sites. In a connected network individual sites benefit one another." Examples include, "Currents; gyres; physical bottlenecks; migration routes; species dispersal; detritus; functional linkages. Isolated sites, such as isolated seamount communities, may also be included" (CBD 2008).

When assessing connectivity, a wide range of species with different dispersal distances and mobilities should be included, as well as considering various life history stages of species (HELCOM 2016; MedPAN & SPA/RAC 2019). However, this is an immensely difficult task, especially at the regional level because MPAs protect such a wide range of species with a range of life history traits. Within the context of ecological coherence assessments, connectivity is generally measured in terms of species dispersal and/or species mobility. Connectivity assessments generally either assess the number of connections between MPAs within a certain distance or measure the distance between MPAs. Marine connectivity is a more complex concept than the other three main criteria, thus a more detailed explanation of connectivity is provided below. Connectivity of an MPA network can be analyzed through the landscape connectivity framework. One approach for analyzing landscape connectivity is to divide it into two broad types: functional and structural connectivity (Taylor et al. 2006).

2.6.3.1 Functional Connectivity

In the context of ecological coherence, functional connectivity is generally related to species movement patterns. Many marine species have varied capacity for movement based on their development stage (larval, juvenile, and adult) (Table 2). Larval dispersal, which is determined by physical ocean processes (structural connectivity – see below) and larval behavior, is an important consideration in MPA network design (Planes et al. 2009), but it can be difficult to incorporate because of the large variety of larval dispersal patterns among different species (IUCN-WCPA 2008). One approach to incorporate larval dispersal in MPA design is to ensure that individual MPA size matches the dispersal distance of the species, and space MPA such that they allow the populations to emigrate/immigrate (IUCN-WCPA 2008). However, there is very little information on the dispersal characteristics of most marine species. An MPA network design that may suit the larval dispersal of one species is unlikely to be suitable for other species, which makes it especially challenging to incorporate (Wells et al. 2008). Recent research indicates that dispersal distances are actually smaller than previously thought (Palumbi 2004; Cowen et al. 2006; Almany et al. 2007; Shanks 2009). Cowen et al. (2006) found that the larval dispersal distance for a variety of reef fish in the Caribbean is between 10 and 100 km. Some species also disperse in their juvenile life stage, which also makes this stage important for connectivity. For instance, some species spend their juvenile stage in coastal habitats, such as seagrass beds or mangroves, before moving to deeper waters as adults (UNEP-WCMC 2018).

Adult movement patterns are also crucial for connectivity of MPA networks. For non-migratory adult species, the size of individual MPAs can be based on the movement range of the species being protected, such that the MPAs are large enough to protect the species during their adult stage, and the spacing of the MPAs should be based on the larval dispersal distance of the species (Palumbi 2004). When protecting multiple species, by protecting the species with the largest adult movement patterns, species with smaller adult movement distances are also protected (Palumbi 2004). Migratory species have the largest movement ranges, making them difficult to protect with MPAs. MPA networks have not been designed for the protection of these species, but it is important that MPA networks at least protect key areas of the life history patterns of migratory species, such as breeding, feeding, and nursery areas (IUCN-WCPA 2008).

Table 2. Approximate adult and larval movement ranges (adapted from Palumbi 2004 and IUCN-WCPA 2008).

Movement Range (km)	**Adult**	**Larval**
>1000s	Large migratory species	Many species
100s – 1000s	Large pelagic fish	Some fish
10s – 100s	Most benthic fish and smaller pelagic fish	Most fish; most invertebrates
1 – 10s	Small benthic fish; many benthic invertebrates	Algae; planktonic direct developers; few fish
<1	Sessile species; species with highly specialized habitat needs	Benthic direct developers

Another important aspect to note is the importance of connectivity of multiple habitats. In tropical areas, connectivity between reef and non-reef areas, particularly mangroves, seagrass beds, and reefs, is especially important (Earp et al. 2018; Mumby 2006). In the Caribbean, certain species use seagrass and/or mangrove habitats as juveniles and reef as adults (Mumby 2006). Connectivity between these habitats also promotes ecosystem resilience. For example, mangroves in the Caribbean can increase the resilience of reefs after a disturbance (Mumby and Hastings 2008). Also, mangrove and coral reef connectivity increases herbivory on the reef, which promotes resilience (Mumby and Hastings 2008). The transfer of nutrients that occurs when these habitats are connected is extremely important (Earp et al. 2018; Wells et al. 2008). Therefore, connectivity between these habitats should be considered.

2.6.3.2 Structural Connectivity

Structural connectivity is important to consider in assessing connectivity of MPA networks. Ocean movement such as current, upwelling, gyres, and thermohaline circulation can play major roles in the distance and direction of larval dispersal (White et al. 2019). The movement of nutrients and organic matter are also important for connectivity, as the transport of nutrients is vital for primary productivity and shaping the ecology of an area (UNEP-WCMC 2018).

Structural and functional aspects of the marine environment form ecological linkages that should be maintained within MPA networks. A connected MPA network should provide ecological linkages in the network, including (IUCN-WCPA 2008):

- Connections of adjacent or continuous habitats
- Connections through larval dispersal between and within MPAs

- Settlement of larvae from one MPA to another
- Movement or mature marine life in their home range

An ecologically coherent MPA network should maximize connectivity between MPAs, between groups of MPAs, and between MPA networks. To do this, MPA networks should ensure (Wells et al. 2008):

- Exchange of offspring through larval dispersal
- Movement of juveniles and adults
- Ecosystem linkages through transfer of materials

2.6.4 Adequacy

An MPA network is adequate if the sites are of sufficient size and protection status to safeguard the features they are meant to protect. An adequate MPA network is also distributed in such a way that it minimizes the impact of threats, both natural and anthropogenic. According to CBD (2008), "adequate and viable sites indicate that all sites within a network should have size and protection sufficient to ensure the ecological viability and integrity of the feature(s) for which they were selected." Adequacy depends on "size; shape; buffers; persistence of features; threats; surrounding environment (context); physical constraints; scale of features/processes; spillover/compactness" (CBD 2008).

Ecological coherence assessments generally assess adequacy with tests for level of protection, threats, and/or size. Level of protection is often measured as the proportion of MPAs that are strongly protected or the proportion of the region that is strongly protected (MedPAN & SPA/RAC 2019). Threats are not always included as a component of adequacy in ecological coherence assessment, but when they are, the goal is to have the network designed in a way to minimize the pressures from threats, generally by measuring the proportion of areas within the MPA system that are not impacted by threats (MedPAN & SPA/RAC 2019; Wolters et al. 2015).

The size of the MPAs should ideally be considered on an individual basis and should be reflective of the conservation objectives of the MPA. On a basic level, MPAs that are protecting more mobile species need to be larger than MPAs protecting species with limited mobility. But the size may be determined by the purpose of the site, adult dispersal, larval dispersal, minimum viable population, habitat continuity, or anthropogenic threats (Sciberras et al. 2013). The rule of thumb is that an individual MPA should be of sufficient size to support a self-sustaining population of a species with a relatively short dispersal distance (MedPAN & SPA/RAC 2019). Based on this rule of thumb, most ecological coherence assessments assess size by comparing the MPA sizes to a set minimum MPA size that is equivalent to a short dispersal distance.

2.7 Case Studies of Ecological Coherence Assessments

To date, comprehensive ecological coherence assessments have only been conducted in waters surrounding Europe, specifically the North Atlantic, the Baltic Sea, and the Mediterranean Sea. This technique for analyzing MPA networks could be applied to other regions to provide valuable information about the status of other MPA networks.

Overall, there are very few guidelines that provide a systematic methodology for conducting an ecological coherence assessment. However, there has been a common overall approach which is to divide the main assessment criteria (usually representativity, replicability, connectivity, and adequacy) into sub-criteria and evaluate them using various "tests" using spatial analysis against specific targets/thresholds (Table 3; Appendix A). There is no agreed upon set of tests, thus different assessments used different tests - although there is some overlap. There is also no agreed upon set of target values, and the assessments generally note that setting target values for the tests is difficult because scientific evidence is often lacking.

Table 3. Assessment criteria and sub-assessment criteria commonly used in ecological coherence assessments.

Main Criteria	**Sub-Criteria**
Representativity	• Coverage of marine region • Biogeographic zones • Depth zones • Habitats • Species
Replication	• Habitats • Biogeographic zones
Connectivity	• Distance between MPAs • Distance between habitats
Adequacy	• MPA size • Level of protection • Proportion of habitats protected

Some, but not all, of the assessments have a methodology for aggregating the results of the tests to give a final measure of ecological coherence. HELCOM (2016) and the European Commission report (Wolters et al. 2015) both used the same one-out-all-out principle for the final measure.

All the ecological coherence assessments conducted thus far have determined that their corresponding MPA networks are *not* ecologically coherent. It has proved to be difficult to verify that a network *is* ecologically coherent, especially compared to how easy it is to assign the designation of *not* ecologically coherent (by failing a single test). This has been stated by OSPAR (2007): "Because ecological coherence is a holistic concept reliant on many constituent parts, it is much easier to develop tests that indicate when it has not been achieved (i.e. some of the parts are missing) than it is to test when it has been achieved (i.e. when all the parts are present and interacting as expected)".

The following sections summarize the process of conducting ecological coherence assessments in various MPA networks. A table comparing the tests used in each case study is in Appendix A.

2.7.1 OSPAR

OSPAR, the mechanism by which national governments and the EU protect the Northeast Atlantic marine environment, has been the global frontrunner in ecological coherence of MPA networks. In 1994, OSPAR was subdivided into 5 regions for assessment and monitoring purposes (OSPAR 2013). In 1998, OSPAR ministers agreed to promote the establishment of an MPA network throughout all five regions (OSPAR 2013), and in 2003, the OSPAR Commission agreed to establish these networks and ensure they are ecologically coherent and well-managed. Many of the MPAs in OSPAR were established through the Natura 2000 process and other MPA sites were selected by national legislation and local initiatives. Since many of the MPAs were not originally established with a systematic approach in mind, the ecological coherence assessment was developed to determine if the MPAs - taken as a whole - can act as a cohesive network and determine where the gaps are. The OSPAR ecological coherence assessments focus on the four main criteria: adequacy/viability, representativity, replication, and connectivity.

Per the OSPAR method, ecological coherence should be stated as a likelihood of ecological coherence, on a continuum between "very unlikely to be ecologically coherent" to "very likely to be ecologically coherent". The point on this continuum is determined by conducting progressively more detailed tests until a test is not met. With this methodology, the tests establish where the network is *not* ecologically coherent, rather than definitively outlining where the network *is* ecologically coherent. OSPAR sets the threshold values for each test and it is important to note that these thresholds are not targets for the MPA network, but rather minimum levels.

The first attempt to establish a comprehensive assessment of ecological coherence was undertaken by OSPAR in 2007 (Ardron 2008b; OSPAR 2008). A second assessment was completed in 2012 (Johnson et al. 2014; OSPAR 2013), and a third in 2016 (OSPAR 2017). In 2006, OSPAR developed general principles of an ecologically coherent MPA network and in 2007 three initial tests were developed and used to assess the ecological coherence of the network. This first assessment was carried out as a step to reach the overarching goal of achieving an ecologically coherent network of MPAs by 2010 (Ardron 2008b). For this initial assessment, three simple tests were proposed to determine whether the MPA network is *possibly* coherent. The thresholds in this initial assessment were set rather arbitrarily, as research for more scientifically-sound thresholds was lacking (Ardron 2008b), and were as follows (Ardron 2008b):

1. Whether the MPAs are well distributed.
2. Whether the MPA network covers at least 3% of most (7/10) relevant Dinter biogeographic provinces (Dinter 2001).
3. whether the MPA Network represents most (70%) of the OSPAR threatened and/or declining habitats and species.

In this assessment, the first two tests were not met and the third test could not be applied because the necessary data was not available at the time (Ardron 2008b). The results of these tests were a stark message that the network was not ecologically coherent and there was much progress to be made to reach the 2010 goal of ecological coherence.

After the initial assessment, OSPAR moved to a stepwise approach for assessing ecological coherence, starting with an initial basic assessment (Level 1 tests) and then using more detailed and sophisticated assessments (Level 2 tests) if the first tests are passed. The 2012 assessment (Johnson et al. 2014; OSPAR 2013) was comprised of these two levels of testing. Level 1 testing was applied to the entire OSPAR Maritime Area and Level 2 tests were applied to certain sub-regions that had more complete data and contained a greater number of MPAs. The Level 1 tests in this assessment were just an expansion of the three tests in the initial assessment, with the third test relating to representativity of bathymetric zones rather than threatened/declining habitats/species. Overall, this assessment was comprised of eight tests. The 2012 assessment concluded that the OSPAR MPA network is not ecologically coherent at a whole, but there are some positive signs.

In the most recent assessment in 2016, a task group further developed the criteria used to assess ecological coherence in the OSPAR MPA network (OSPAR 2017). This task group developed "The Madrid Criteria", which are three initial spatial tests that reflect the key network principles of ecological coherence. The 2017 report indicates that improvements have been made to improve ecological coherence, but it still cannot be considered as an ecologically coherent MPA network (OSPAR 2017).

2.7.2 HELCOM

HELCOM, the intergovernmental organization protecting the Baltic Sea, has produced a comprehensive assessment of ecological coherence of the MPA network in the region. As with OSPAR, HELCOM agreed to complete an ecologically coherent network of MPAs by 2010 (HELCOM 2010). With 10.3% of its marine area protected, HELCOM was the first marine region to achieve Aichi Target 11 (HELCOM 2010).

The assessment considered four criteria: representativity, replication, adequacy, and connectivity. The thresholds set for representativity and connectivity were partly met in the assessment. The thresholds for replication were mostly met, and the thresholds for adequacy were not met. Overall, this indicated that the network is not ecologically coherent (HELCOM 2016). Similar to OSPAR, HELCOM admits that science-based thresholds for some of the targets are still missing.

Unlike the OSPAR assessments, the HELCOM assessment attempted to quantitatively aggregate the results of the tests. This aggregation indicated that it is highly unlikely that the network is ecologically coherent. This method first uses weighted averaging of the subcriteria that considers the result, threshold, uncertainty in the data, uncertainty in the threshold, and uncertainty in the method. Then an average of all sub-criteria under each main criteria is calculated and the likelihood for reaching the target is given for each criterion. Finally, the one-out-all-out principle is applied to the four main criteria, such that the criterion with the lowest score determines the final assessment result. HELCOM recommends their aggregation approach because of its straightforward and transparent methods and plans to use it in the future (HELCOM 2016). Overall, the HELCOM methodology follows the methodology outlined by Wolters et al. (2015) for the European Commission (see section 2.7.4).

2.7.3 Mediterranean Sea

A partial ecological coherence assessment of the Mediterranean Basin was conducted in 2016 (MedPAN & SPA/RAC 2019). This assessment was part of "The Status of Marine Protected Areas in the Mediterranean Sea – 2016 Edition" report and it is not a comprehensive ecological coherence assessment. Rather, it is a preliminary analysis and summary of potential tests. This assessment incorporates the four main criteria of ecological coherence: adequacy, connectivity, replication, and representativity but no overarching conclusions as to the ecological coherence of the Mediterranean Basin can be drawn from this report.

2.7.4 European Commission

An independent study was commissioned by the Directorate-General for Environment, which is the European Commission department responsible for EU policy on the environment. The aim of this study was to harmonize the methodology for the evaluation of ecological coherence of European MPA networks, with the goal that it can be applied to different regions and scales in the European seas (Wolters et al. 2015).

The report recommends using basic assessment methods in situations where data is limited and more ecologically accurate assessments cannot be made (Wolters et al. 2015). For this basic assessment, only shapefiles of the region, bathymetry, MPA polygons, and species and habitats found within the MPAs are needed (Wolters et al. 2015). If more data is available, the report recommends a more detailed assessment, which requires mapped data of the ranges of habitats/species/other features of interest and spatial distribution of anthropogenic pressures (Wolters et al. 2015).

This report suggests using the one-out-all-out principle of the four main criteria (representativity, replication, connectivity, and adequacy), as they are all equally important. This means that a failure of one criterion to achieve ecological coherence results in an overall failure to achieve ecological coherence (Wolters et al. 2015). The proposed methodology also includes uncertainty in the assessment to identify gaps in the assessment. Uncertainty can be added to data, targets, and methods and is included in the final aggregation of the sub-criteria and main criteria.

The proposed methodology was tested in the central part of the Baltic Sea. After running each of the tests for the study area, uncertainty was added, then the weighted average was calculated, which resulted in a measure of the likelihood of reaching the target in each criterion (very unlikely, unlikely, likely, and very likely). Ecological coherence was "unlikely" to have been reached for representatively, connectivity, and adequacy, and "very likely" to have been reached for replication. Overall, ecological coherence is *unlikely* to be reached in the Baltic Sea test area.

2.7.5 The Celtic Seas

The Celtic Seas, a region of OSPAR, was assessed by Foster et al. (2017) for ecological coherence. As opposed to the other European case studies presented, which were regional-level assessments, this ecological coherence assessment was done at a sub-regional level. The assessment overall found that the MPA network is not ecologically coherent, but progress has been made and it meets of Aichi Target 11 of 10% coverage by MPAs. The assessment found major gaps in the network, such as a lack of MPAs in offshore areas.

Foster et al. (2017) broadly followed the OSPAR methodology of first running a spatial assessment that considers the spatial arrangements and characteristics of the network, and then assessing the network with "the matrix approach" (Foster et al. 2017). However, the specific tests that were run in this study did not exactly match the tests used by OSPAR. Additionally, some of the recommendation thresholds differed from those used by OSPAR. In this study, threshold recommendations came from Roberts et al. (2003; 2010), Jackson et al. (2008), Rondinini (2011), Halpern and Warner (2003), and Natural England and the Joint

Nature Conservation Committee (2010). This study did not have a system to aggregate the results of the tests into a final measure of ecological coherence.

2.7.6 California

To date, the concept of ecological coherence has only been applied to MPA networks in European waters. MPA networks have, of course, been established elsewhere in the world, but they have not been assessed using the ecological coherence approach. For example, the MPA network in California is planned and designed using criteria similar to the criteria used to assess ecological coherence, but it has not formally been assessed for ecological coherence.

California was the first state in the US to establish an MPA network (Murray and Hee 2019; Wenzel et al. 2020). The state has been praised for its comprehensive approach to establishing an MPA network that integrated scientific knowledge, local communities, potential economic impacts, and innovative technology (Murray and Hee 2019). A science advisory team developed science guidelines for MPA network design that were later applied to evaluate each MPA network proposal against each other (Kirlin et al. 2013). These science-based guidelines contained four criteria for the spatial configuration of the MPA network: MPA size, MPA spacing, habitat representation, and habitat replication (Saarman et al. 2013). These four criteria are similar enough to be compared against the four criteria used in ecological coherence assessments. Unlike in ecological coherence assessments though, the science advisory team in California did not come up with specific thresholds for each of the criteria because the criteria were not used to assess a completed network. Rather, the criteria are used to compare various proposals for MPA network design against each other. Nonetheless, the evaluation approach for these criteria are useful for understanding ideal MPA network designs and various approaches to assessing MPAs networks outside of Europe.

2.8 Background Information on the Caribbean Marine Environment

The Caribbean has the greatest diversity of marine species in the Atlantic Ocean (Roberts et al. 2002; Miloslavich et al. 2010). The Caribbean also contains over 7% of the world's coral and is home to the world's second largest reef, the Mesoamerican reef (Burke and Maidens 2004; Gress et al. 2019). Seagrass and mangrove habitats are also common along the coastal areas. The majority of corals and associated species are endemic to the region, making the Caribbean a region of great biodiversity importance (Burke and Maidens 2004; Miloslavich et al. 2010).

Marine resources are critical for human well-being in the Caribbean (Chakalall et al. 2007). Many Caribbean countries, especially the small island developing states (SIDS), are highly dependent on the marine environment for economic needs, as well at recreational, cultural, and spiritual needs (Fanning et al. 2011). However, the marine environment in the Caribbean is highly threatened by anthropogenic pressures. It is threatened by coastal development, sedimentation and pollution, climate change, disease, and overfishing (Burke and Maidens 2004). In fact, its fisheries are among the most overexploited in the world (FAO 2014).

Marine protection is essential in the region to protect fish stocks, as well as to conserve biodiversity and other resources and preserve cultural values (Bustamante and Vanzella-Kouri, 2011). However, the Caribbean is incredibly politically complex, which makes marine protection especially difficult. The Caribbean may have the highest concentration of countries and territories of anywhere in the world (Spalding and Kramer 2004), each with different goals and capacities regarding marine conservation. There are hundreds of MPAs in the Caribbean, with widely varying degrees of protection (Dalton et al. 2015). Despite the large number of MPAs, they do not form a cohesive network of marine protection. Most of the reserves are considered “paper parks”, there are major gaps in MPA coverage, and they do not protect the diversity of habitats in the region (Appeldoorn and Lindeman 2003). These flaws in the MPA system are well known, yet there is a lack of holistic assessments that would highlight specific gaps in the network.

In 1981, the United Nations Environment Programme (UNEP) established the Caribbean Environment Programme (CEP) as one of its Regional Seas Programmes. A few years later, in 1983, the countries of the Caribbean adopted the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region, also known as the Cartagena Convention. The Cartagena Convention is the first and only legally binding environmental treaty of its kind in the region (UNEP-CEP 2021; US EPA 2014). It provides legal framework for the CEP and promotes regional and national action for environmental protection and sustainable development of the Wider Caribbean Region (UNEP-CEP 2021; US EPA 2014). The Cartagena Convention is supplemented by three protocols, each with a different focus: specially protected areas and wildlife (SPAW Protocol); oil spills (Oil Spills Protocol); and land-based sources of marine pollution (LBS Protocol).

In 1997, CEP, in close collaboration with the SPAW protocol, established the Caribbean MPA Managers Network (CaMPAM), a social network aimed at enhancing MPA network effectiveness in the Caribbean. As the only formally established MPA network in the region, CaMPAM brings together individual MPA managers and builds capacity. Before CaMPAM, there were very few efforts that focused on capacity building of Caribbean MPAs (Bustamante et al. 2018). Before CaMPAM, MPAs in the Caribbean had low capacity due to under-qualified managers, understaffing, and lack of funding (Bustamante et al. 2018). Over the past 20+ years, CaMPAM has become a more prominent organization in the region and has developed more resources to help MPA managers in the region effectively manage their MPAs.

Chapter 3: Methodology

This chapter details the methodology applied in this ecological coherence assessment. The methodology is based on previous ecological coherence assessments, especially HELCOM (2016), OSPAR (2008; 2013; 2017), MedPAN & SPA/RAC (2019), Wolters et al. (2015), Foster et al. (2017) and Agnesi et al. (2017). This methodology measures ecological coherence by assessing four main criteria of the MPA network using spatial analysis: representativity, replicability, connectivity, and adequacy. Three or four tests were used to assess each of the four main criteria, for a total of fourteen tests. This chapter justifies each test and its associated target and provides detailed steps for running each test. The methodology used for aggregating the results of the tests to determine a final score of ecological coherence likelihood is also outlined.

3.1 Data Handling

3.1.1 Software

All spatial analysis was conducted in ArcGIS Pro (version 2.5.0). Other data analysis was conducted in Microsoft Excel.

3.1.2 Study Area

The study area is comprised of the EEZs of the countries and territories in the Caribbean Sea and the Gulf of Mexico, from Florida (USA) in the north to French Guiana in the South (Figure 2). The shoreline of the study area was determined by The National Oceanic and Atmospheric Administration (NOAA) World Vector Shoreline (WVS) (NOAA 2017), which is the highest quality free dataset available (Thomas et al. 2014). The eastern marine boundary of the region was defined by the borders of the EEZs of the states and territories of the Caribbean, as downloaded from Flanders Marine Institute (2019). There are two small areas of ABNJ in the Gulf of Mexico. Although they are not part of the EEZ of any country, these areas were included in the study area for this assessment. The total marine area of the study area is over 6.5 million km^2. For tests that did not depend on exact shorelines, a 30 km buffer was made around the borders of the study area to ensure that marine features that extend beyond the official shoreline (e.g. mangroves) are included in the analysis.

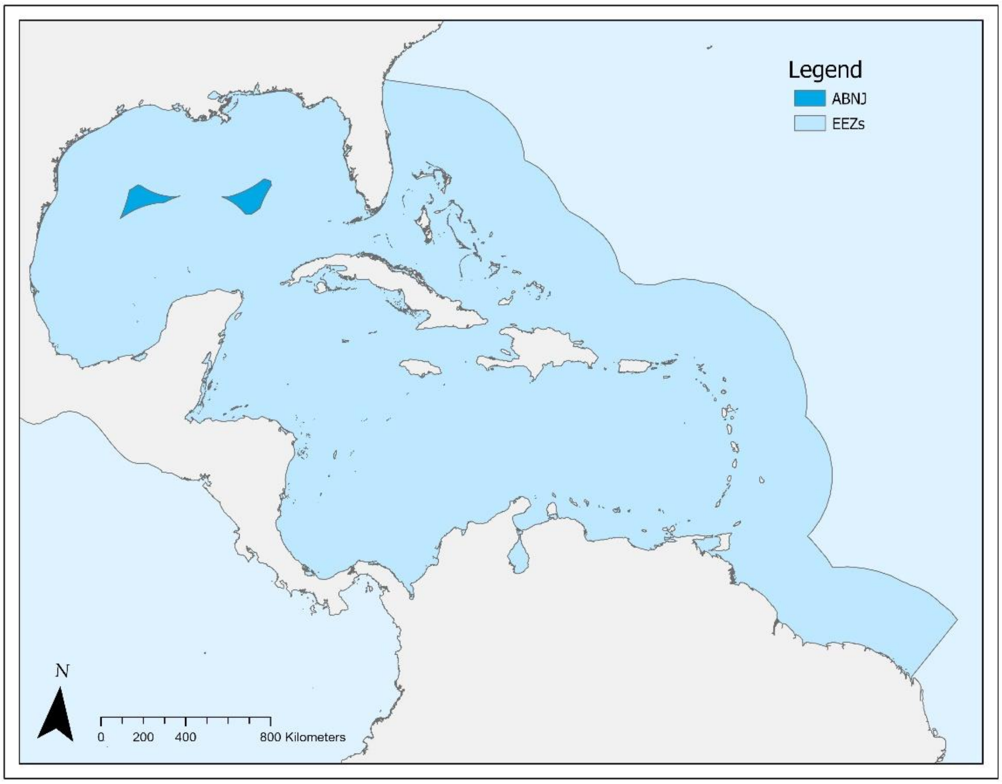

Figure 2. EEZ area and ABNJ within the study area. The EEZs of the countries and territories within the study area have been dissolved into a single layer. Data Sources: Flanders Marine Institute (2019); NOAA (2017).

The study area was divided into nine subregions, as defined by Burke and Maidens (2004), to analyze the data at a smaller scale (Figure 1). Due to the large number of states and territories in the region, including many small island nations and territories, the more detailed analyses were done at the subregional, rather than national level. There are not official subregions in the Wider Caribbean Region, but the subregions as defined by Burke and Maidens (2004) work well because they are based on a combination of EEZ boundaries and ecoregions.

3.1.3 MPAs

The MPA data was downloaded from The World Database of Protected Areas (WDPA) (UNEP-WCMC & IUCN 2021d). I generally followed the methodologies outlined in the WDPA Manual (UNEP-WCMC 2019; Thomas et al. 2014) to verify and process the data before conducting any analyses. I first clipped the worldwide polygon and point data of protected areas to an area that reached 30 km beyond the study region to reduce processing times (the data was clipped again later in the process, see below). I then created polygons from the point data. While most of the WDPA data are polygons, some protected areas are reported as points. To include the points, I buffered each point to the area of its reported marine area (as provided by the data provider). Points without a reported area were excluded.

Next, the buffered points were merged with the polygon data. Next, The United Nations Educational, Scientific and Cultural Organization (UNESCO) Man and Biosphere sites were removed, as suggested by Thomas et al. (2014), because of the low precision of the data location and area calculations. The dataset prepared at this point was used only with the habitat analyses (henceforth known as the “habitat MPA layer”). Another dataset derived from this dataset was used for all other analyses (henceforth known as the “MPA layer”), as described below.

To prepare the MPA layer the WDPA data was clipped to the study area (NOAA WVS along the coast, the EEZ boundaries in the marine boundary). However, because of some alignment issues between the WDPA layer and the NOAA WVS layer, there were a number of small slivers of terrestrial protected areas accidentally in the marine area that should not have been there. To remove as many of these slivers as possible, Thomas et al.’s (2014) methodology was employed for the MPAs that overlapped with the coastline, as follows. The clipped marine portion of coast-overlapping sites were identified as MPAs in this assessment if more than 100 hectares of the site fell in the marine environment, or more than 10 hectares of the site fell in the marine environment and this represented more than 30% of the site (Thomas et al. 2004). I calculated the areas of coast-overlapping sites in marine environments and removed the coast-overlapping sites that did not meet either of these criteria. This process resulted in exactly 900 MPAs (or parts thereof) that were considered in the assessment (see Appendix G for a list of these MPAs).

Many of the MPAs in the MPA layer and habitat MPA layer are overlapping. For most tests, these layers were dissolved together into single layer. This resulted in a flat layer of MPA “footprints”, rather than individually demarcated MPAs. Dissolving the MPAs removed the significant overestimation of MPA coverage that would occur from double counting overlapping MPAs. This process resulted in 3,605 MPA footprints.

3.1.4 No-Take MPAs

No-take MPA layers were created from the MPA layer and the habitat MPA layer by removing all MPAs except those that are designated as all or partly no-take in the WDPA database. It should be noted that there is no spatial information on the parts of MPAs that are no-take, thus the entirety of MPAs that are designated as partly no-take are included in these analyses (see section 5.2). There were 74 no-take MPAs considered in this assessment.

3.1.5 Biogeographic Zones

Biogeographic zones were used in several tests in the assessment. The biogeographic zones used were ecoregions and pelagic provinces, from the "Marine Ecoregions and Pelagic Provinces of the World" dataset (The Nature Conservancy 2012) developed by Spalding et al. (2007; 2012) and downloaded from UNEP-WCMC's Ocean Data Viewer[1]. The study area was divided into non-overlapping ecoregion and pelagic province zones (Figure 3). The use of ecoregions was prioritized over pelagic provinces because they have more specific characterizations, but areas that did not have ecoregions were assigned pelagic provinces instead. The study area is made up of 11 ecoregions and 5 pelagic provinces, for a total of 16 biogeographic zones.

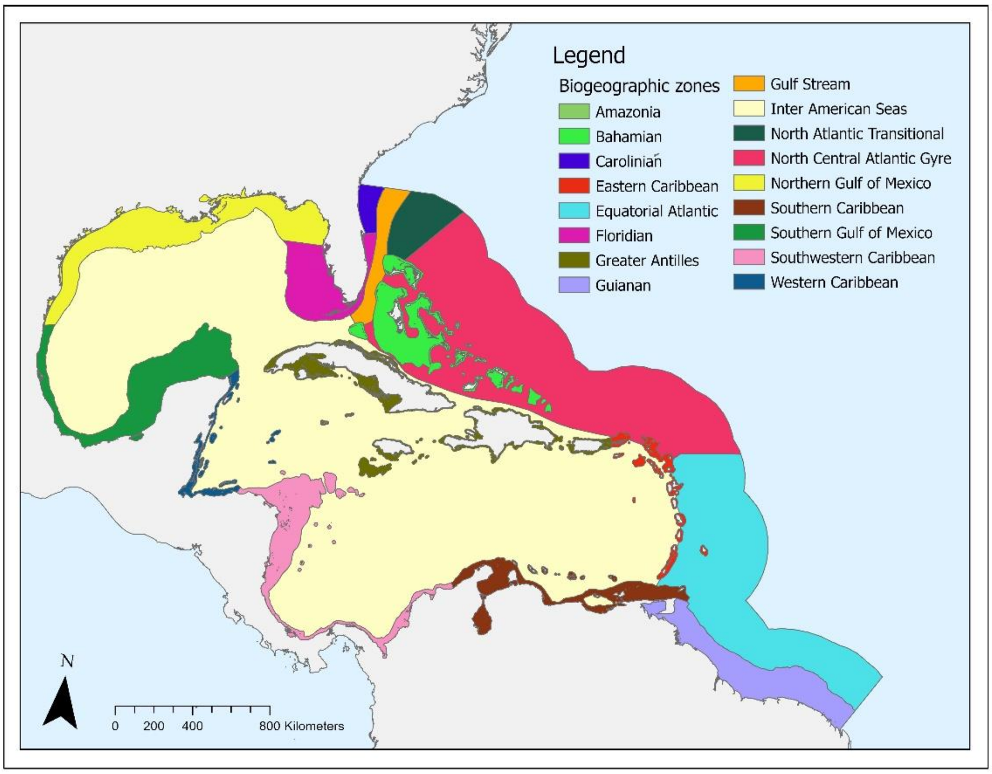

Figure 3. The biogeographic zones within the study area. Data sources: Flanders Marine Institute (2019); NOAA (2017); The Nature Conservancy (2012).

[1] https://data.unep-wcmc.org/

3.1.6 Habitats

The habitat information in this assessment was made up of 13 habitat types: eight hard and soft bottom benthic habitats and five other habitats (Figure 4).

The eight benthic habitats are split into hard and soft habitats in four depth ranges:

- Hard shallow (0-60 m)
- Soft shallow (0-60 m)
- Hard shelf (60-200 m)
- Soft shelf (60-200 m)
- Hard slope (200-2000 m)
- Soft slope (200-2000 m)
- Hard deep (>2000 m)
- Soft deep (>2000 m)

This data comes from a global dataset of benthic habitats produced by Halpern et al. (2019). The original data is from benthic core samples taken around the world as part of the dbSEABED project. Halpern et al. (2019) used the point data from the core samples and used kriging to classify the unsampled locations. Each of these eight habitats was a separate raster image that was then clipped to the study area and converted to polygons for analysis.

The five other habitats included in this assessment were mangroves (Bunting et al. 2018), coral reefs (UNEP-WCMC et al. 2021), saltmarshes (Mcowen et al. 2017), seagrasses (UNEP-WCMC & Short 2021), and seamounts (Yessen et al. 2011). All of these were vector global datasets downloaded from UNEP-WCMC's Ocean Data Viewer. The coral reef, saltmarsh, and seagrass data all also had associated point data without area information. The coral reef and seagrass point data were included by buffering the points to an area of 1 km^2 and merging it with the respective polygon layer. The 1 km^2 area was chosen to reflect occurrence without assuming size. The saltmarsh point data was not included because the data provider recommended against using the point data in spatial analysis, as it is included for reference only (Mcowen et al. 2017). These five layers were clipped to the study area. Cold-water coral habitat data was not included in this assessment because it was only available as point data without a size associated with it. To reduce processing times, the seagrass dataset and saltmarsh datasets were both simplified with the simplify polygons tool.

They were simplified using the retain bends option with a tolerance of 500 meters. All the habitat layers were dissolved before running any analyses.

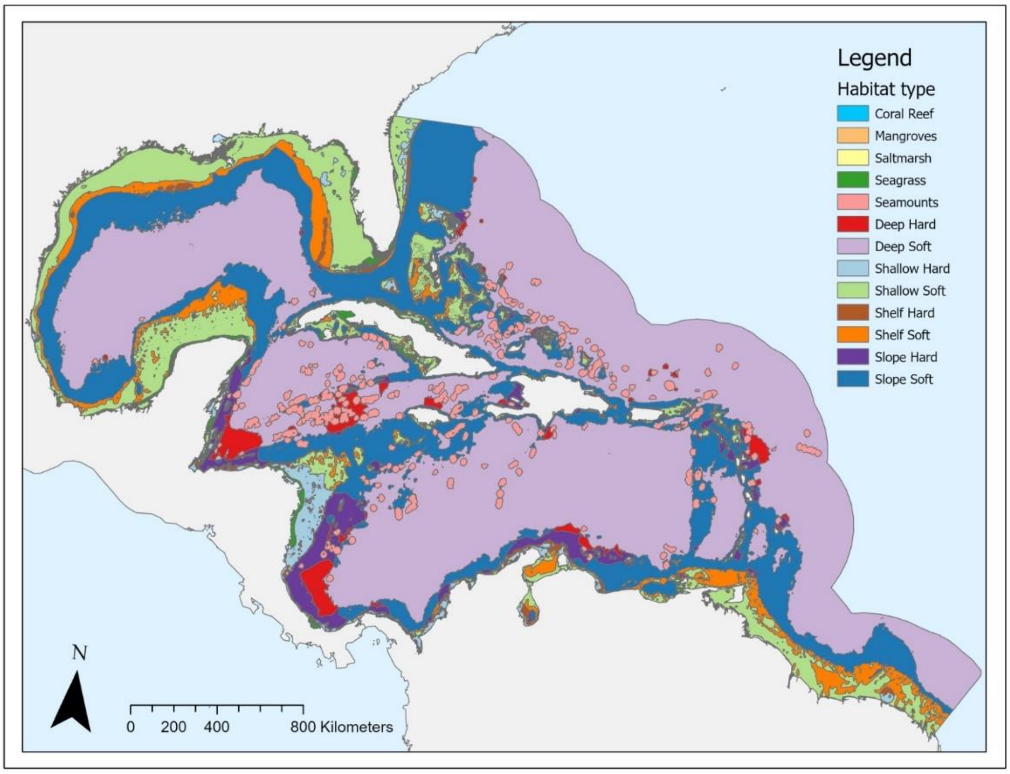

Figure 4. Habitats used in this assessment. Data sources: Flanders Marine Institute (2019); NOAA (2017); Halpern et al. (2019); Mcowen et al. (2017); UNEP-WCMC & Short (2021); UNEP-WCMC et al. (2021); Bunting et al. (2018); Yesson et al. (2011).

3.2 Representativity

3.2.1 General Coverage

Explanation, rationale, and threshold

The percent of the Wider Caribbean Region that is covered by MPAs was calculated at a regional and sub-regional scale. The global target for conserving 10% of coastal and marine areas (CBD 2008) was applied as the threshold (Table 4). While not an explicit test in all ecological assessments, this is a basic test that gives a general overview of whether the CBD target of 10% marine coverage of MPAs has been met in the most minimal fashion. This test is included in ecological assessments of the Baltic Sea (HELCOM 2016) and the Celtic Seas (Foster et al. 2017) and proposals for a European-wide ecological coherence assessment (Wolters et al. 2015; Agnesi et al. 2017).

Although the 10% threshold was established by the CBD as a target for biodiversity protection, rather than an ecological coherence assessment threshold, this threshold has been the norm in the literature for tests of representativity (HELCOM 2016; Wolters et al. 2015; Foster et al. 2017; Agnesi et al. 2017). According to Wolters et al. (2015), “There is a CBD target of 10% coverage…the target is well-established and we did not consider alternative targets.”

Methodology

General coverage was calculated by first calculating the total area of the region and each subregion covered by MPAs, then dividing this by the total area of the region.

1. The total area of the region and subregion was determined by calculating the geodesic area of each subregion of the study area using an equal-area projection (Mollweide).
2. The MPA layer was dissolved into a single layer to eliminate double-counting overlapping areas.
3. The calculate geometry function was used to calculate the geodesic area of total MPA coverage within the study area using an equal-area projection (Mollweide).
4. MPA coverage per subregion was calculated by first running an intersect analysis with the MPA layer and the subregion layer. The result showed areas covered by MPAs in each subregion.
5. The calculate geometry function was used to calculate the geodesic area of MPA coverage per subregion using an equal-area projection (Mollweide). From this, the percentage of MPA coverage per subregion was calculated.

Table 4. The thresholds for all tests used in this assessment.

	Test	Threshold
Representativity	General coverage	10% MPA coverage
	Biogeographic zones	10% coverage of each biogeographic zone
	Ecologically important areas	10% coverage of ecologically important areas
	Habitats	10% coverage of each habitat
Replicability	Biogeographic zones	3 replicates (4 patches) with a minimum patch size of .24 km^2
	Biogeographic zones in no-take MPAs	3 replicates (4 patches) with a minimum patch size of .24 km^2
	Habitats	3 replicates (4 patches) with a minimum patch size of .24 km^2
	Habitats in no-take MPAs	3 replicates (4 patches) with a minimum patch size of .24 km^2
Connectivity	Distance between MPAs	75% of MPAs should be within 20 km of another MPA
	Distance between no-take zones	75% of no-take zones should be within 20 km of another no-take zone
	Distance between protected habitats	75% of MPAs containing a certain habitat type should be within 80km of another MPA containing the same habitat type (with a minimum patch size of .24 km^2).
Adequacy	Size of MPAs	75% of MPAs should be at least 5 km^2
	Level of protection	30% of MPAs should be no-take
	Human Impact	75% of MPA area should be in the 75% least impacted areas

3.2.2 Coverage of Biogeographic Zones

Explanation, rationale, and threshold

Biogeography is an important consideration in both the site selection and MPA network design process, as well as in MPA network assessments (Gubbay 2014). Existing protected areas are not representative of marine ecosystems. As of 2020, only half of the world's marine ecoregions and only 13.5% of the pelagic provinces have met the 10% protection target (UNEP-WCMC, IUCN & NGS 2021).

Previous ecological coherence assessments have used biogeography in their tests of representativity (OSPAR 2008; OSPAR 2013; OSPAR 2017; MedPAN & SPA/RAC 2019; Wolters et al. 2015; Foster et al. 2017). In this assessment I used ecoregions and pelagic provinces as defined by Spalding (2007) as a measure of biogeographic representativity. The Mediterranean ecological coherence assessment (MedPAN & SPA/RAC 2019) also used Spalding et al.'s (2007) ecoregions. Ecoregions are defined by Spalding et al. (2007) as, "Areas of relatively homogeneous species composition, clearly distinct from adjacent systems. The species composition is likely to be determined by the predominance of a small number of ecosystems and/or a distinct suite of oceanographic or topographic features. The dominant biogeographic forcing agents defining the eco-regions vary from location to location but may include isolation, upwelling, nutrient inputs, freshwater influx, temperature regimes, ice regimes, exposure, sediments, currents, and bathymetric or coastal complexity."

The percent of each ecoregion that is contained within the MPA network was calculated using the "Marine Ecoregions and Pelagic Provinces of the World" datasets (The Nature Conservancy 2012), which is a combination of "Marine Ecoregions of the World" (Spalding et al. 2007) and "Pelagic Provinces of the World" (Spalding et al. 2012). A threshold of 10% was applied to this test, in accordance with the MedPAN & SPA/RAC (2019) and OSPAR (2017) assessments.

Methodology

1. The biogeographic zone data was compiled as explained in section 3.1.5.
2. The biogeographic zones were clipped to the extent of the study region.
3. The calculate geometry function was used to calculate the geodesic area of each biogeographic zone in an equal-area protection (Mollweide).
4. The MPAs layer was dissolved and intersected with the clipped biogeographic zones.
5. From this resulting layer, the geodesic area of each biogeographic zone that is covered by MPAs was calculated with the calculate geometry function in an equal-area projection (Mollweide). This was then divided by the total area of each biogeographic zone to get the final percentage.

3.2.3 Coverage of Ecologically Important Areas

Explanation, rationale, and threshold

This test determined the percentage of ecologically important areas that are protected in the region. A test for ecologically important areas is not commonly used in the Regional Seas Programme's tests for ecological coherence. The only assessment that used it was

Mediterranean ecological coherence assessment (MedPAN & SPA/RAC 2019). A similar test was also mentioned, but not completed, in OSPAR (2013). Including ecologically and biologically significant areas in MPA networks has been clearly stated in IUCN guidelines for establishing MPA networks (IUCN-WCPA 2008). One of the five ecological guidelines for designing resilient MPA networks is “ensure ecologically significant areas are incorporated” (IUCN-WCPA 2008). In Green et al. (2013) protecting critical habitats and special or unique sites are included in the ecological guidelines for designing MPA networks in tropical ecosystems. Following these recommendations in MPA design literature, I decided to include this test in my assessment of the Caribbean region.

As this test has only been used by MedPAN & SPA/RAC (2019) and there is no clear precedent for a threshold level, I used the 10% threshold that was used in that report. However, there is an argument to be made for a higher threshold level for this test. Ecologically important areas are, by definition, of higher importance compared to other surrounding areas so it would make sense to use a higher threshold level for these areas. Other reports have used varying threshold levels for other tests, depending on rarity. For example, HELCOM (2016) raised the threshold for rare habitats (60%) compared to common habitats (20%) and Wolters et al. (2015) also used a 20% threshold for some features and a 40% threshold for other features.

The ecologically important areas that were included in the test are “ecologically and biologically significant areas” (EBSA), “key biodiversity areas” (KBA), “important bird areas” (IBA) and “alliance for zero extinction” (AZE) (BirdLife International 2021). The KBA, IBA and AZE data are all in one dataset (BirdLife International 2021), and most of the areas in the dataset fall into more than one of the three designations.

Methodology

1. The individual EBSA polygons were merged into a single layer.
2. Point data was converted to polygons. Some of the KBA/IBA/AZE data were points, rather than polygons. To convert them to polygons, they were buffered to be the size equal to the reported area of the site. The radius of a circle that would result in an area of the desired size was calculated and this was used at the buffer distance.
3. The KBA/IBA/AZE point data was merged with the polygon data and then merged with the EBSA data.

4. The EBSA/KBA/IBA/AZE (henceforth: critical habitats) data was then clipped to the study area and dissolved to remove overlaps.
5. An intersection was run with the dissolved critical habitats and the MPA layer. The result was a layer of the critical habitat areas that are contained in MPAs. The geodesic area of the critical habitats in MPAs was calculated using an equal-area projection (Mollweide).
6. An intersection was also run with critical habitats and the subregions to determine area of each subregion that is critical habitat. The geodesic area of each the critical areas in each subregion was calculated using an equal-area projection (Mollweide).
7. The layer resulting from step 5 was intersected with the subregion layer to determine the area of critical habitat that is protected within each subregion. The geodesic area was calculated using an equal-area projection (Mollweide).

3.2.4 Coverage of Habitats

Explanation, rationale, and threshold

A key component of representativity as defined by the CBD (2008) is to capture the full range of ecosystems, including habitat diversity. Therefore, a test for the representativity of habitats is crucial for assessing representativity of the MPA network. Although testing for habitat representativity is a crucial component, there is no standard methodology for habitat representativity in the literature. The two general approaches are: 1) a target percent that MPAs should cover of each habitat type (HELCOM 2016; MedPAN & SPA/RAC 2019; Wolters et al. 2015), or 2.) a target of at least one example of each habitat type represented in an MPA per region or study area (OSPAR 2017; OSPAR 2013; Foster 2017). For this study, I compared the percentage of each habitat type contained within MPAs to a threshold (approach 1 above).

There is general agreement in the literature that threshold values should vary by habitat, with more rare or important habitats having higher threshold values. For instance, HELCOM (2016) set the threshold at 20-60% protection for common habitats and 60% protection for rare habitats. However, with a lack of region-wide information on the importance of various habitats, a 10% target for all habitat types was used, as in MedPAN & SPA/RAC (2019).

I used both broad scale benthic habitats and the major marine and coastal habitats in the Caribbean region (saltmarshes, seagrass beds, coral reefs, mangroves, and seamounts) in this test. See section 3.1.6 for the preparation process.

An inherent flaw with this test is that it does not consider if the habitat type is necessary protected by the MPA, but with a study at this large of a scale, the management plans of the individual MPAs cannot be considered (see section 5.4.1).

Methodology

1. The study region was buffered to 30 km to ensure it will encompass mangroves inland of the official shoreline.
2. All 13 individual habitat layers were merged into a single habitat layer and clipped to the buffered study region.
3. The geodesic area of each habitat was calculated using calculate geometry in an equal-area projection (Mollweide).
4. The habitat layer was intersected with the habitat MPA layer and the geodesic area was calculated in equal-area projection (Mollweide) to determine how much of each habitat type is contained in MPAs.

3.3 Replication

Explanation, rationale, and threshold

Ecological coherence assessments test for replicability of MPA sites containing a particular feature. The general trend among previous assessments is to either test for replication at the broad scale of biogeographic zones (Saarman et al. 2013; Wolters et al. 2015), or at the finer scale of habitats (Foster et al. 2017; OSPAR 2013; OSPAR 2017). Only in HELCOM (2016) was replication tested at both scales. Because this is the first ecological coherence assessment in the Caribbean and there is no precedent testing for replicability in this study area, I followed the HELCOM (2016) guidelines and tested for replicability at both scales.

Some literature also calls for considering level of protection in replication. For instance, Fernandes et al. (2009 and 2012) suggests at least 3-4 replicates of habitats within no-take areas in the Great Barrier Reef (Fernandes et al. 2009) and in her guidance for designing an

MPA network in the Coral Triangle (Fernandes et al. 2012). As such, I included tests for replicability in no-take zones at both scales as well.

Thresholds for the minimum number of replicates needed to pass the replication test vary widely between ecosystem assessments. The lowest minimum threshold is 1 replicate (2 patches) (Wolters et al. 2015) and the highest minimum threshold in the literature is 5 replicates (6 patches) (Saarman et al. 2013). For both tests, I set the threshold at 3 replicates (4 patches), as it is near the average value used in other assessments. I also set a minimum patch size of .24 km^2, as used in HELCOM (2016) and Foster et al. (2017).

An inherent flaw with this test is that it does not consider if the biogeographic zones/ habitats are necessary protected by the MPA, but with a study at this large of a scale, the management plans of the individual MPAs cannot be considered (see section 5.4.1).

3.3.1 Replication of Biogeographic Zones

Replication of protection of biogeographic zones by MPAs was calculated at the regional level. The number of replicates is the number of MPA patches containing at least one ecoregion patch with a minimum size of .24 km^2 minus one. To pass the test, there must be at least 3 replicates (4 patches) of each ecoregion protected in MPAs in the region. This test will be conducted once for all MPAs and once for no-take MPAs.

Methodology

1. The MPA layer was dissolved to remove overlap. In this dissolve function, multipart features were not created, so that each polygon remained a separate feature. This resulted in separate MPA "footprints".
2. These MPA footprints were intersected with the biogeographic zone layer. This resulted in patches of biogeographic zones contained in MPAs.
3. The geodesic areas of the intersecting polygons were calculated using an equal-area projection (Mollweide) and patches smaller than .24 km^2 were removed.
4. The number of patches of each biogeographic zone contained in MPAs was counted using the "summarize field" function.

Methodology for No-Take Zones:

Replication of biogeographic zones within no-take MPAs followed the same methodology as above, except using the no-take MPA layer (see section 3.1.4) instead of the MPA layer.

3.3.2 Replication of Habitats

Replication of habitats within MPAs was calculated at the regional level. The number of replicates is the number of MPA patches containing at least one habitat patch with a minimum size of .24 km^2 minus one. To pass the test, there must be at least 3 replicates (4 patches) of each habitat protected in MPAs in the region. This test was conducted once for all MPAs and once for no-take zones.

Methodology

1. The study region was buffered to 30 km to ensure it will encompass mangroves inland of the official shoreline.
2. All 13 individual habitat layers were merged into a single habitat layer and clipped to the buffered study region.
3. The habitat MPA layer was dissolved to remove overlap. In this dissolve function, multipart features were not created, so that each polygon remained a separate feature. This resulted in separate MPA "footprints".
4. These MPA footprints were intersected with the habitat layer. This resulted in patches of habitats contained within MPAs.
5. The geodesic areas of the intersecting polygons were calculated using an equal-area projection (Mollweide) and patches smaller than .24 km^2 were removed.
6. The number of patches of each habitat contained in MPAs was counted using the "summarize field" function.

Methodology for No-Take Zones:

Replication of habitats within no-take MPAs followed the same methodology as above, except using the no-take habitat MPA layer (see section 3.1.4) instead of the habitat MPA layer.

3.4 Connectivity

In general, mechanisms for ensuring strong connectivity in MPA networks have not been fully developed (Wells et al. 2008), thus it is very difficult to measure for connectivity. However, MPA coherence assessments have come up with a number of tests that measure basic connectivity. In MPA coherence assessments, connectivity has been tested either as a measure of **distance** or **number of connections**. For distance tests, MPAs should not be spaced more than a threshold distance depending on distance from shore (OSPAR 2008; 2013; 2017), or habitat (OSPAR 2013; Foster et al. 2017; Saarman et al. 2013; Agnesi et al. 2015), or solely based on distance (MedPAN & SPA/RAC 2019; Wolters et al. 2015). For connectivity tests based on number of connections, the tests either test for the number of connections between MPAs at theoretical dispersal distances (HELCOM 2016) or between MPAs of the same habitat (HELCOM 2016) compared to a threshold number of connections. Only HELCOM (2016) tested for number of connections.

3.4.1 Distance Between MPAs and No-Take MPAs

Explanation, rationale, and threshold

As the majority of ecological coherence assessments test connectivity with distance, I used distance as the measure of connectivity. Green et al. (2013) recommends that MPAs in tropical areas should be no more than 20 km apart. This distance encompasses the majority of variability in larval dispersal distances in tropical regions, which are lower than previously thought (Almany et al. 2007; Shanks 2009). Fernandes et al. (2012) suggested the common range of larval dispersal is 100 m to 1 km to 30 km. For this test, 75% of MPAs in the region should be within 20 km of another MPA. The 75% threshold was used by Agnesi et al. (2017) in a similar distance-based connectivity test for ecological coherence. A second level of this test will be conducted, such that 75% of no-take zones in the region should be within 20 km of another no-take zone, as Fernandes et al. (2012) specifically recommends separating no-take zones by 1-20 km.

Methodology

1. The MPA layer was dissolved to remove overlap. In this dissolve function, multipart features were not created, so that each polygon remained a separate feature. This resulted in separate MPA “footprints”.

2. The geodesic area of the individual footprints was calculated in an equal-area projection (Mollweide) and footprints smaller than .24 km^2 were removed from the analysis, as per OSPAR (2012) and HELCOM (2016).
3. The MPA footprints were buffered with 10 km buffers in an equidistant projection (Azimuthal Equidistant) centered on the Caribbean region.
4. The buffered layer was intersected with itself to highlight the MPA footprints with overlapping buffers. MPA footprints with overlapping buffers means that they are closer than 20 km.
5. Using select by location, the MPAs with the overlapping buffers were selected and made into a new layer. At this stage, the number of MPAs with overlapping buffers (the "connected" MPAs), could be compared to the number of MPA footprints without overlapping buffers (the "not connected" MPAs).

Some limitations: In this method, some multi-part MPAs might be counted as multiple MPAs during the dissolving step. Also, MPAs on different sides of islands might be counted as connected even though there is land between them.

Methodology for No-Take Zones:

Connectivity of no-take MPAs followed the same methodology as above, except using the no-take MPA layer (see section 3.1.4) instead of the MPA layer.

3.4.2 Distance Between Habitats

Explanation, rationale, and threshold

This test measures whether protected habitat patches are connected. Many ecological coherence assessments measure connectivity based on distance between the same habitat types (OSPAR 2013; Foster et al. 2017; Saarman et al. 2013; Agnesi et al. 2017), each with slightly different methodology. For my assessment, I followed Foster et al.'s (2017) methodology and threshold level, such that the MPA network is deemed connected if there are less than 80km between MPAs containing the same habitat type (with a minimum patch size of .24 km^2).

Methodology

1. The MPA layer was dissolved to remove overlap. In this dissolve function, multipart features were not created, so that each polygon remained a separate feature. This resulted in separate MPA "footprints".
2. The MPA footprint polygons were intersected with each habitat layer individually. Patches of less than .24 km were removed from the analysis (Foster et al. 2017).
6. Working with each habitat individually, the protected habitat patches were buffered with 40 km buffers using an equidistant projection (Azimuthal Equidistant) centered on the Caribbean region.
3. The buffered layers were intersected with themselves to highlight the MPA footprints with overlapping buffers for each habitat. MPA footprints with overlapping buffers means they are closer than 80 km.
4. Using select by location, the MPA footprints with the overlapping buffers were selected and made into a new layer. At this stage, the number of MPAs with overlapping buffers (aka the "connected" MPAs), could be compared to the number of MPA footprints without overlapping buffers (aka "not connected" MPAs).

Some limitations: This test does not consider if the habitat type is necessary protected by the MPA. With a study at this large of a scale, the management plans of the individual MPAs cannot be considered.

3.5 Adequacy

3.5.1 Size of MPAs

Explanation, rationale, and threshold

Adequacy tests relating to the size of MPAs are extremely common in the literature, with nearly all previous ecological coherence assessments running such tests (OSPAR 2013; HELCOM 2016; Wolters et al. 2015; Foster et al. 2017; Saarman et al. 2013; Agnesi et al. 2017; MedPAN & SPA/RAC 2019). MPAs should be of a sufficient size to ensure that species and habitats can persist. The size of an individual MPA will depend on the individual objectives of the MPA and the specific species it is aiming to protect. However, the general rule of thumb is that the individual MPAs should be at least big enough to be self-sustaining for species with relatively short dispersal distances (MedPAN & SPA/RAC 2019).

To assess the size of MPAs within a network, many ecological coherence assessments decide on a minimum MPA size and a proportion of MPAs that should be at least that size. For example, HELCOM's (2016) threshold was that 80% of MPAs should be at least 30 km^2 and Agnesi et al. (2017) suggested that 75% of MPAs should be greater than 5 km^2. Wolters et al. (2015) suggested a 20 km^2 minimum (without a threshold proportion). I followed the methodology of Agnesi et al. (2017) in my assessment. Agnesi et al. (2017) intentionally split the data into specific size classes of 0-5 km^2, 5-30 km^2, 30-100 km^2, and greater than 100 km^2. The 5 km^2 class flags the very small MPA sites that may not be large enough for population viability. The 30 km^2 class is the minimum cut-off set by HELCOM (2016). The 100 km^2 class indicates the number of MPAs that have met Edgar's et al. (2014) claim that MPAs of 100 km^2 should be the target size.

Methodology

1. Calculate the geodesic areas of all the MPAs in the MPA layer using an equal-area projection (Mollweide).
2. Export the attribute table of the MPA layer to excel for analysis of the distribution of MPA sizes.

3.5.2 Level of Protection

Explanation, rationale, and threshold

Adequacy is often thought of as mostly relating to size and shape of protected areas, but level of protection is an important aspect as well. MPAs must be protected to a high enough degree that the features they are protecting maintain their ecological viability. MPAs with stricter levels of protection are considered the most effective, especially for replenishing fish stocks (Sala and Giakoumi 2017; Giakoumi et al. 2017).

Both HELCOM (2016) and Wolters et al. (2015) assessed the level of protection as the proportion of MPAs designated as no-take zones. Wolters et al.'s (2015) threshold was that 30% of sites should be no-take, and HELCOM (2016) used a 10-30% threshold as recommended by the Fifth World Parks Congress in 2003. I used Wolters et al.'s (2015) threshold that 30% of sites should be no-take.

Methodology

1. Export the attribute table of the MPA layer to excel.
2. Calculate the percentage of no-take MPAs per subregion from the number of no-take MPAs and total MPAs per subregion.

3.5.3 Human Impact

Explanation, rationale, and threshold

MPAs should be distributed in such a way that human impacts are minimized (MedPAN & SPA/RAC 2019). It is important to include human impacts in the assessment because areas of human impacts can help identify areas of conservation concern - where there is an overlap of high biodiversity and high human impact. Such an assessment can also identify areas within MPAs with high human impact, an indicator of poor protection.

A couple of assessments have included tests for human impact, but there is no standard or well-proposed methodology for how to include it. For instance, in the Baltic Sea, anthropogenic pressures such as fishing, boat traffic and eutrophication, are overlayed with MPAs to assess adequacy but no threshold is set (HELCOM 2016). Wolters et al. (2015) suggests identifying major human threats, estimating the impact range of each threat, and comparing that to MPA locations to see how MPAs are affected by various threats. In that approach, an arbitrary target was set for the area of MPAs that should be unaffected by pressures.

Based on previous unpublished work by Cameron Bullen (pers. comm.) I have developed a test for assessing human impact using the cumulative human impact data developed by Halpern et al. (2019). This data combines data from four primary categories: fishing stressors (e.g. commercial demersal destructive), climate change stressors (e.g. ocean acidification), ocean stressors (e.g. shipping), and land-based stressors (e.g. nutrient pollution). This test determines the percentage of MPAs in the region that are not highly impacted by anthropogenic activities. This test divided the marine region into the 25% most impacted areas and the 75% least impacted areas and determined the percentage of MPAs in each. To pass the test, 75% of MPAs need to be in 75% least impacted areas.

Methodology

1. The raster data of worldwide cumulative human impacts was clipped to the study area using the mask tool.
2. The raster data was reclassified into quartiles, such that the 25% most impacted locations were given a value of 2, and the other 75% of locations (lower impacted locations) were given a value of 1.
3. Each subregion in the study area layer was assigned a unique identification number. This was converted to raster.
4. The MPA layer was converted to raster, with the MPAs areas assigned an identification number and the non-MPA areas assigned an identification number.
5. Using raster calculator, the MPA raster layer, the reclassified human impact layer, and the subregion layer were all "added". This resulted in two different values for MPAs in each subregion, with the higher value representing a cell that is in a high human impact zone, and a lower value representing a cell that is in a lower human impact zone.
6. For each subregion, the number of cells within MPA areas that were in low impact zones was divided by the total number of cells within MPA areas. This resulted in the percent of MPA area in low impact zones.

3.6 Aggregating the Criteria

To give a succinct answer to whether an MPA network is ecologically coherent, it is necessary to have a methodology for aggregating the results of the assessment. However, there are few methods established for this purpose. Most existing methods rely on expert judgement or do not fully integrate the criteria (Wolters et al. 2015). To address this gap, Wolters et al. (2015) developed a methodology for fully aggregating the results of ecological coherence assessments. This methodology was successfully tested by HELCOM (2016) in their most recent ecological coherence assessment. I use this methodology in my assessment.

The methodology developed by Wolters et al. (2015) uses weighted averaging of the sub-criteria and the one-out-all-out principle for assessing the four main criteria. The one-out-all-out principle means that the failure to meet one of the four target criterion results in overall failure to reach ecological coherence. The method also incorporates uncertainty of the data, targets, and assessment methods (Table 5).

Table 5. Criteria to estimate the level of uncertainty in the assessment. Source: Wolters et al. (2015).

	LOW UNCERTAINTY (1)	**MODERATE UNCERTAINTY (.75)**	**HIGH UNCERTAINTY (.5)**
Data	Data is complete and accurate	Data is party incomplete or not fully reliable	Data is incomplete for several sites
Target	Target is nationally or regionally agreed	Target is tentative	Target is fully arbitrary
Assessment method	Method is ecologically relevant	Method is not ideal or unnecessarily simplified reality	Method is too simple or lacks in ecological reality

The steps of the methodology are as follows (adapted from HELCOM 2016):

1. **The sub-criteria ratio is calculated.** The sub-criteria are the criteria used in each of the tests within the four main criteria. For example, the MPA representativity in the Gulf of Mexico is one of the sub-criterion within the representativity criterion. The ratio is the sub-criteria evaluation result divided by its target. As proposed in HELCOM (2016), this ratio was capped at 2, to prevent disproportionately high values of sub-criteria that greatly exceed their target.
2. **Uncertainties are estimated and included in the aggregating tables.** Uncertainties in the data, target, assessment method for all sub-criteria are estimated as low (1), moderate (.75), or high (.5) based on the guidelines in Table 5. The uncertainty values are then averaged for a mean uncertainty per sub-criterion. A weighted average for each sub-criterion was then calculated using the sub-criteria ratio and sub-criteria uncertainty (sub-criteria ratio x sub-criteria mean uncertainty)
3. **A final score for each main criterion (representativity, replicability, connectivity, adequacy) was calculated.** The final score was calculated by calculating the average of all the sub-criterion weighted averages. The likelihood of each main criterion having reached ecological coherence was given based on the final score (Table 6).

Table 6. Likelihood that the criteria has reached ecological coherence. Source: HELCOM (2016).

Likelihood of ecological coherence being achieved	Score of main criteria
Very unlikely	<.5
Unlikely	.5 - <1
Likely	1 – 1.5
Very likely	>1.5

4. **Finally, the final outcome of the ecological coherence assessment is determined.** The final outcome is determined based on the final scores of each main criterion. This uses the one-out-all-out principle, in that the main criterion with the lowest score determines the final outcome. For instance, even if three of the four criteria have final scores above 1 (“likely” or “very likely”), if one criterion has a score below 1, say .75 (“unlikely”), then the overall outcome is .75.

Chapter 4: Results

4.1 Representativity

4.1.1 General Coverage

The minimum target for the coverage of MPAs in the entire Wider Caribbean Region and the nine subregions was 10% of the total area of each category. Figure 5 shows a map of the results. The target was only reached in three of the nine subregions (Figure 6). At the regional level, 8.10% (530,611 km^2) of the total marine area (6,554,219 km^2) is covered by MPAs (Figure 6). Thus, the target was not reached at the regional level.

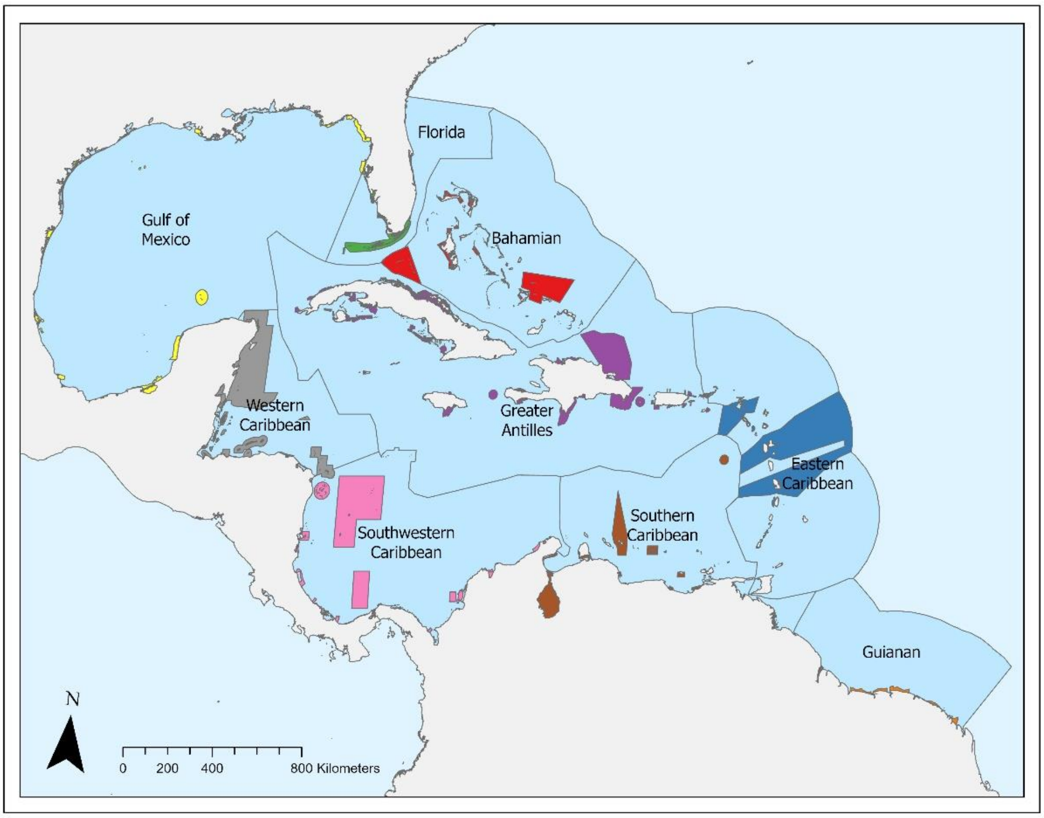

Figure 5. MPA coverage of the Wider Caribbean Region by subregion. A different color is used to represent the MPAs in each of the nine subregions. Calculations were done in an equal-area projection, but the figure is displayed in the Robinson projection to reduce distortion. Data sources: Flanders Marine Institute (2019); NOAA (2017); UNEP-WCMC & IUCN (2021d).

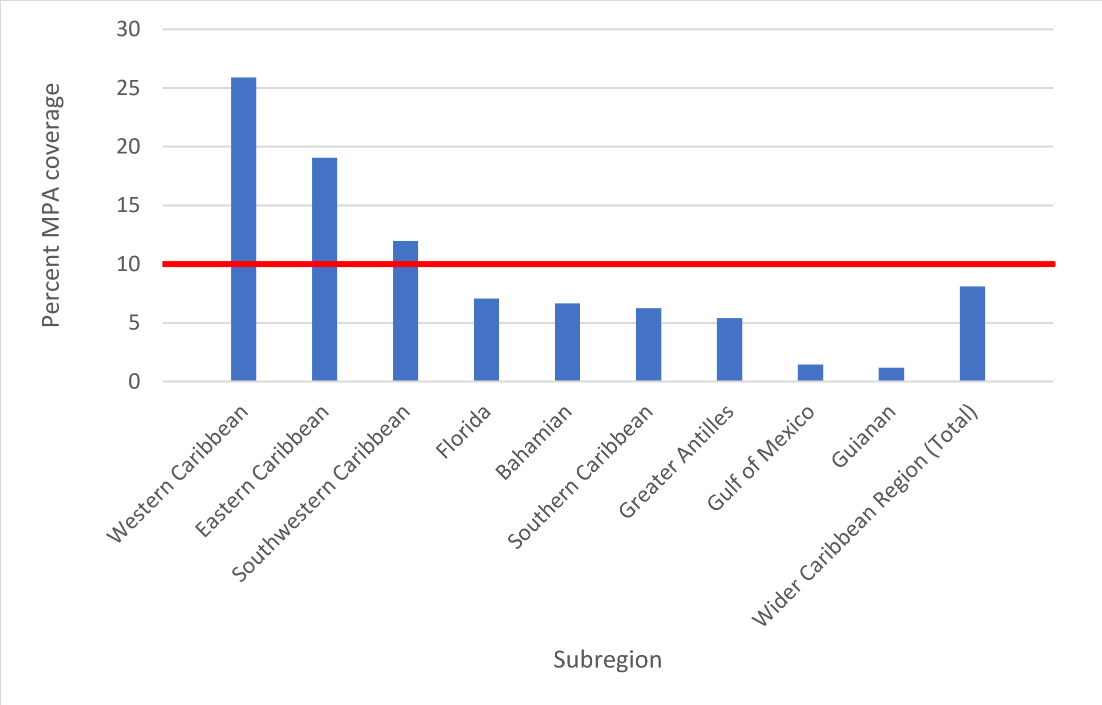

Figure 6. Coverage of MPAs in each subregion of the Wider Caribbean Region and total coverage of the region. The target (red line) is 10% coverage overall and of each subregion.

4.1.2 Coverage of Biogeographic Zones

The target for MPA coverage of each biogeographic zone was 10%. The results of this test are visually represented in Figure 7. Eight of the seventeen biogeographic zones reached the target (Figure 8). The percent of MPA coverage varied widely between the bioregions, with minimum percent coverage (0%) in the North Atlantic Transitional zone and maximum percent coverage in Western Caribbean zone (58.43%).

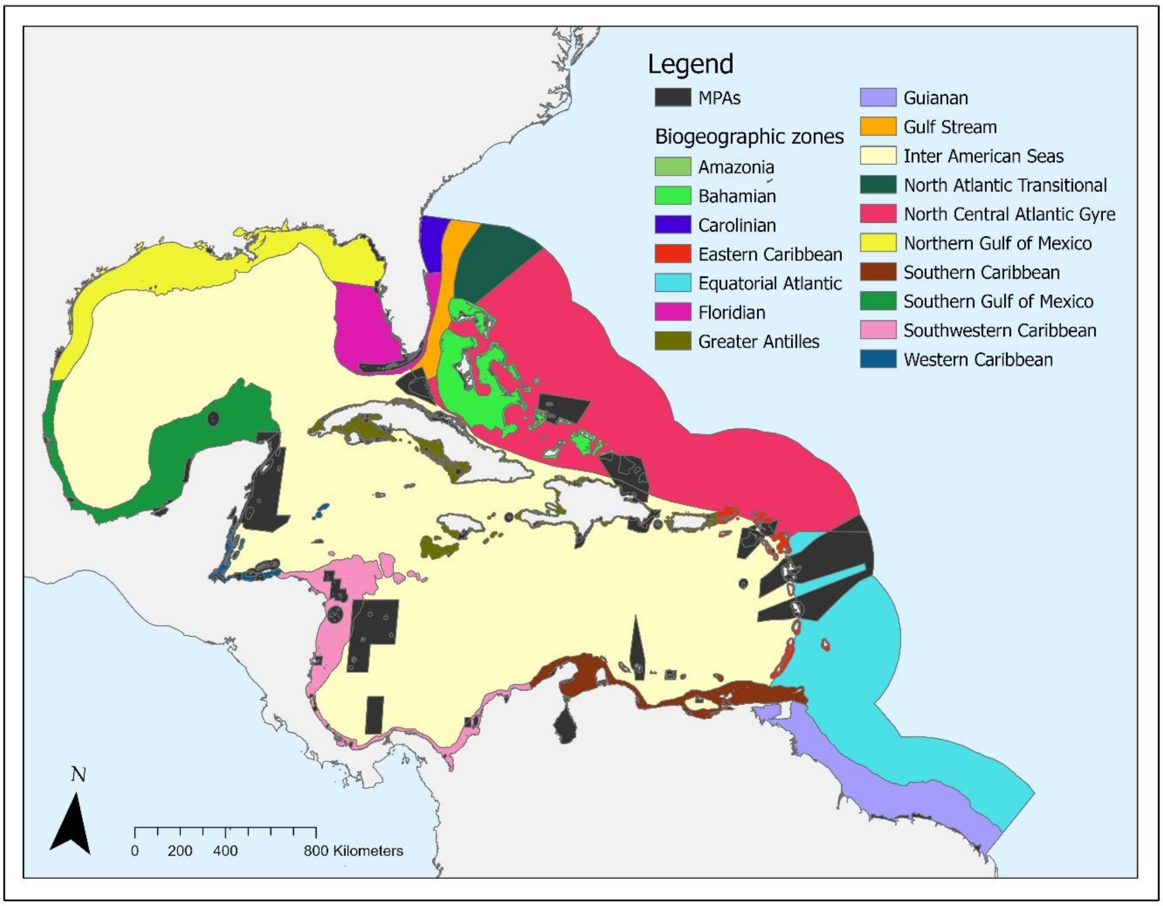

Figure 7. MPA coverage of each biogeographic zone. MPAs are represented by black polygons. Calculations were done in an equal-area projection, but the figure is displayed in the Robinson projection to reduce distortion. Data sources: Flanders Marine Institute (2019); NOAA (2017); UNEP-WCMC & IUCN (2021d); The Nature Conservancy (2012).

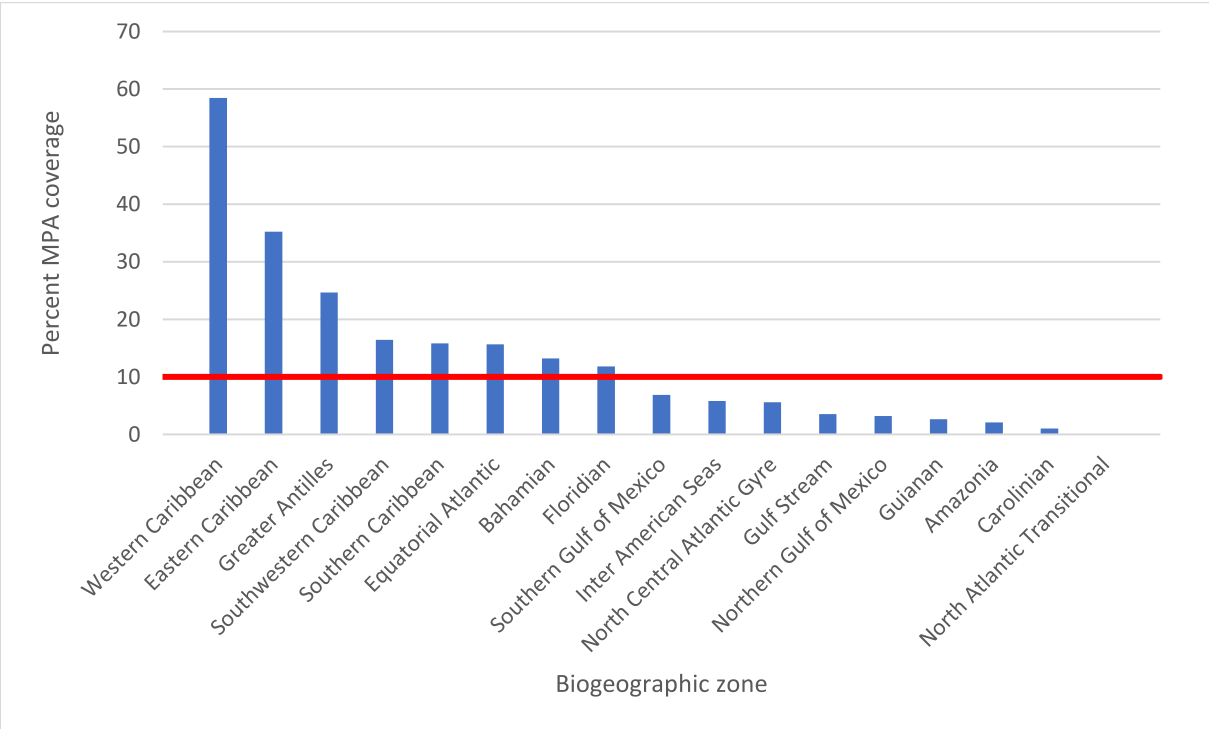

Figure 8. Percent MPA coverage of each biogeographic zone. The target (red line) is 10% coverage of each biogeographic zone.

4.1.3 Coverage of Ecologically Important Areas

The MPA coverage of ecologically important areas was calculated on a subregional and regional scale, with a coverage target of 10% for each subregion and the entire region. The target was exceeded in eight of the nine subregions (Figure 10). The Guianan subregion was the only subregion to not reach the target, with only 1.12% of the ecologically important areas covered by MPAs. However, it should be noted that 99.22% of the Guianan subregion (394,374 km^2) is designated as ecologically important areas (Figure 9). On the other end of the spectrum, 96.80% of the ecologically important areas in the Florida subregion are covered by MPAs, but only 1.69% (3,644 km^2) of the subregion is designated is ecologically important areas (Figure 9). The 10% target was exceeded at the regional level, with 21.28% of ecologically important areas covered by MPAs overall in the Wider Caribbean Region.

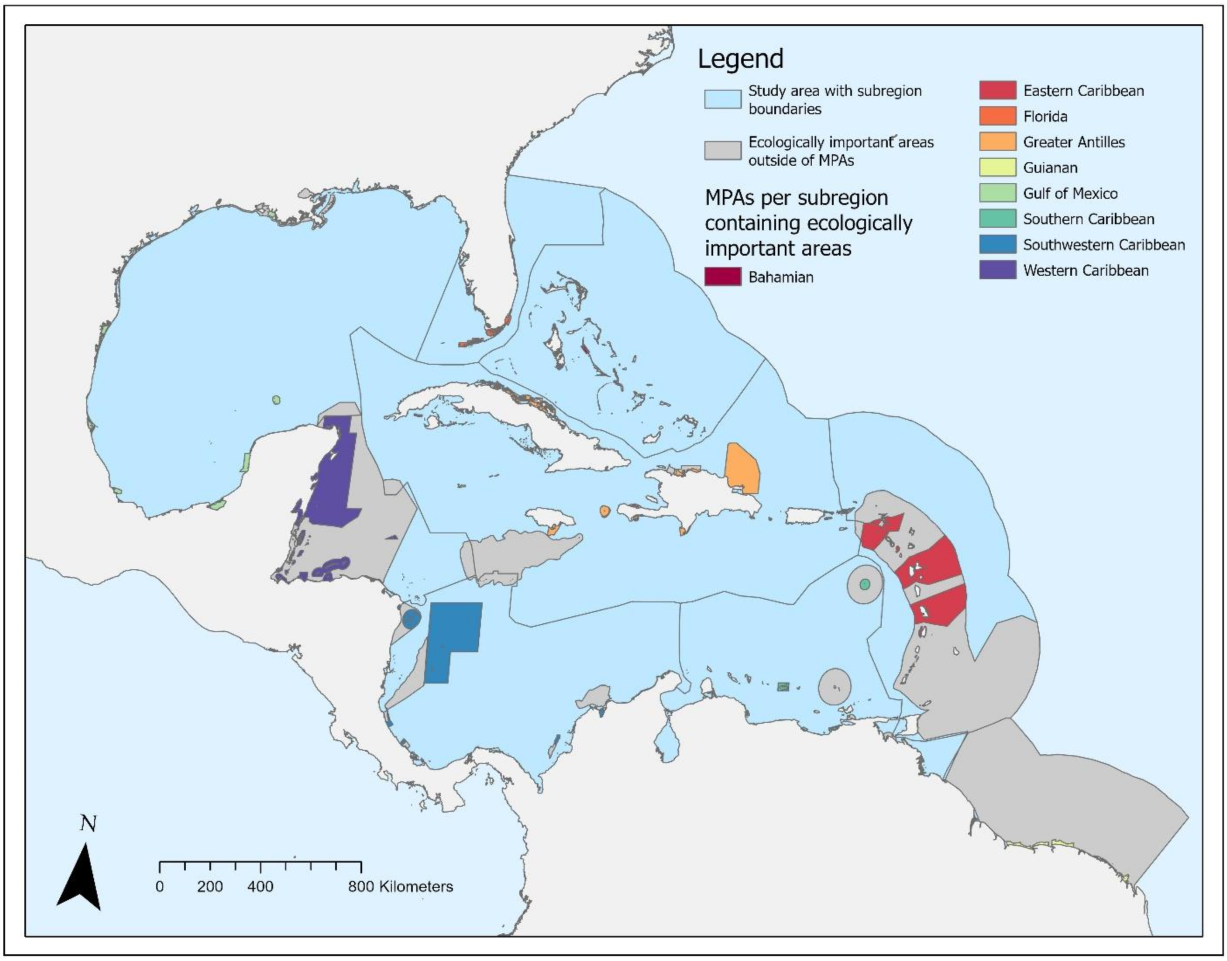

Figure 9. MPA coverage of ecologically important areas. Gray areas represent unprotected ecologically important areas and the colored polygons represent MPAs that cover ecologically important areas in each subregion. Calculations were done in an equal-area projection, but the figure is displayed in the Robinson projection to reduce distortion. Data sources: Flanders Marine Institute (2019); NOAA (2017); UNEP-WCMC & IUCN (2021d); BirdLife International (2021).

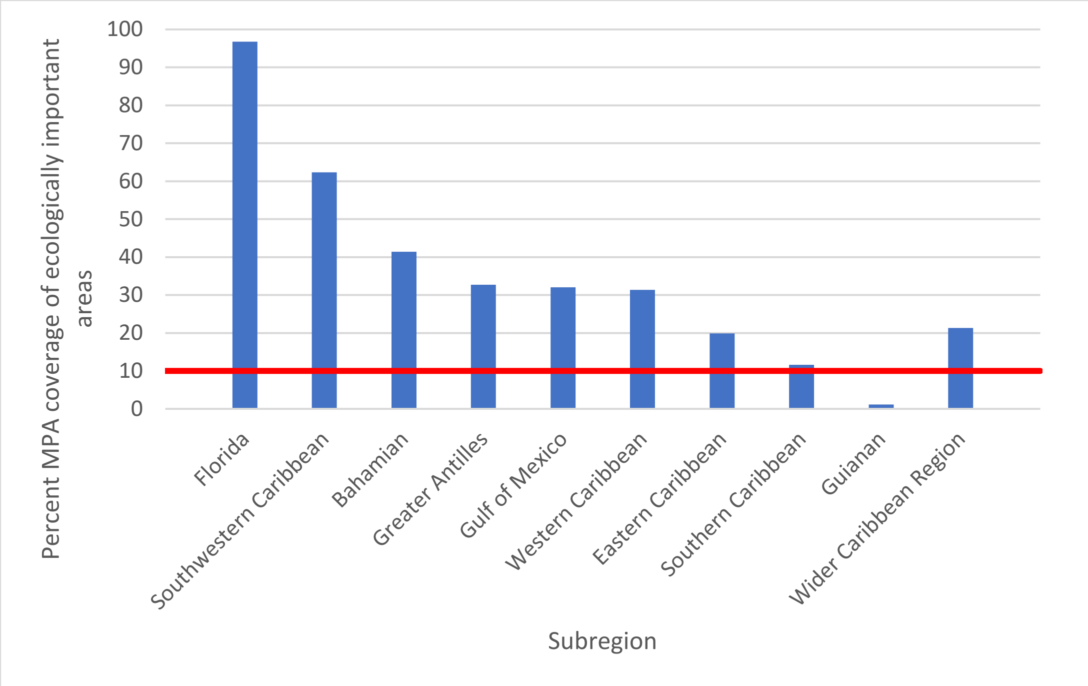

Figure 10. Percent MPA coverage of ecologically important areas in each subregion and in the entire Wider Caribbean Region. The target (red line) is 10% coverage of ecologically important areas.

4.1.4 Coverage of Habitats

The percent coverage by MPAs of each habitat type was calculated for the Wider Caribbean Region with a target coverage of 10% of each habitat type. Figure 11 displays the MPAs overlayed with the thirteen habitat types. Ten of the thirteen habitat types exceeded the 10% target (Figure 12). All five of the specific habitat types (coral reefs, mangroves, saltmarshes, seagrass, and seamounts) exceeded the coverage target (Figure 12). The four habitats with the lowest percent MPA coverage were all four of the soft-bottom benthic habitats (soft shelf, shallow soft, slope soft, and deep soft). These four habitats were also the habitats with the largest areas.

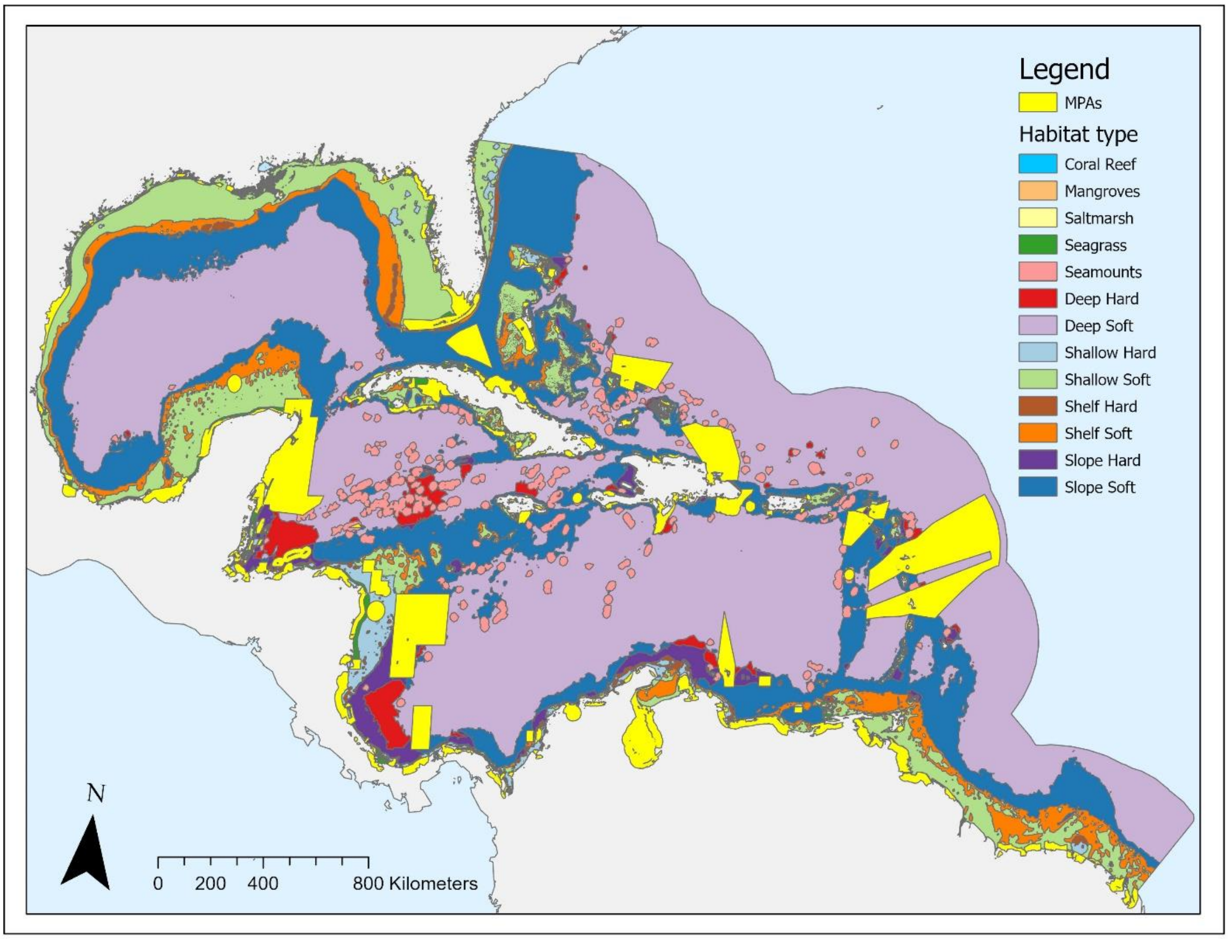

Figure 11. Coverage of habitats within the Wider Caribbean Region MPA network. The locations of the thirteen habitats are each represented by a different color and the MPAs are yellow polygons. Calculations were done in an equal-area projection, but the figure is displayed in the Robinson projection to reduce distortion. Data sources: Flanders Marine Institute (2019); NOAA (2017); UNEP-WCMC & IUCN (2021d); Halpern et al. (2019); Mcowen et al. (2017); UNEP-WCMC & Short (2021); UNEP-WCMC et al. (2021); Bunting et al. (2018); Yesson et al. (2011).

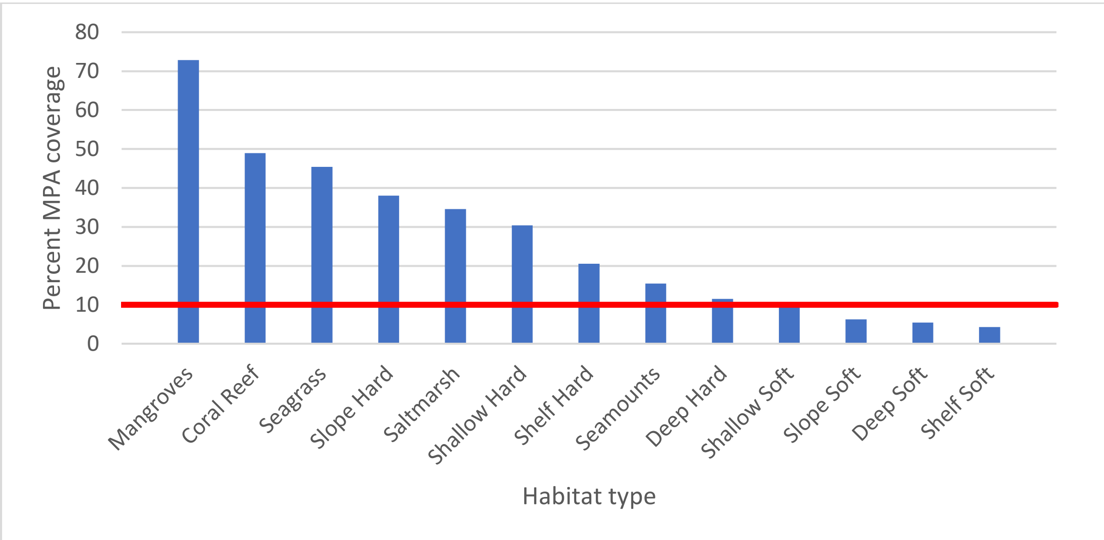

Figure 12. Percent MPA coverage of each habitat type, calculated on the regional level. The target (red line) is 10% coverage of each habitat type.

4.2 Replicability

4.2.1 Replication of Biogeographic Zones

The number of MPA footprints containing at least one biogeographic zone patch was calculated. The target was 3 replicates (4 patches) of each biogeographic zone. Figure 13 shows a map of the biogeographic zone patches covered by the MPAs. The number of replicates of each biogeographic zone is displayed in Figure 14. Thirteen of the seventeen biogeographic zones exceeded the target (Figure 14). Most of the biogeographic zones greatly exceeded the target, with eleven of the seventeen biogeographic zones exceeding 20 replicates (ten times the target). The zone with the greatest number of replicates was Greater Antilles, with 162 replicates.

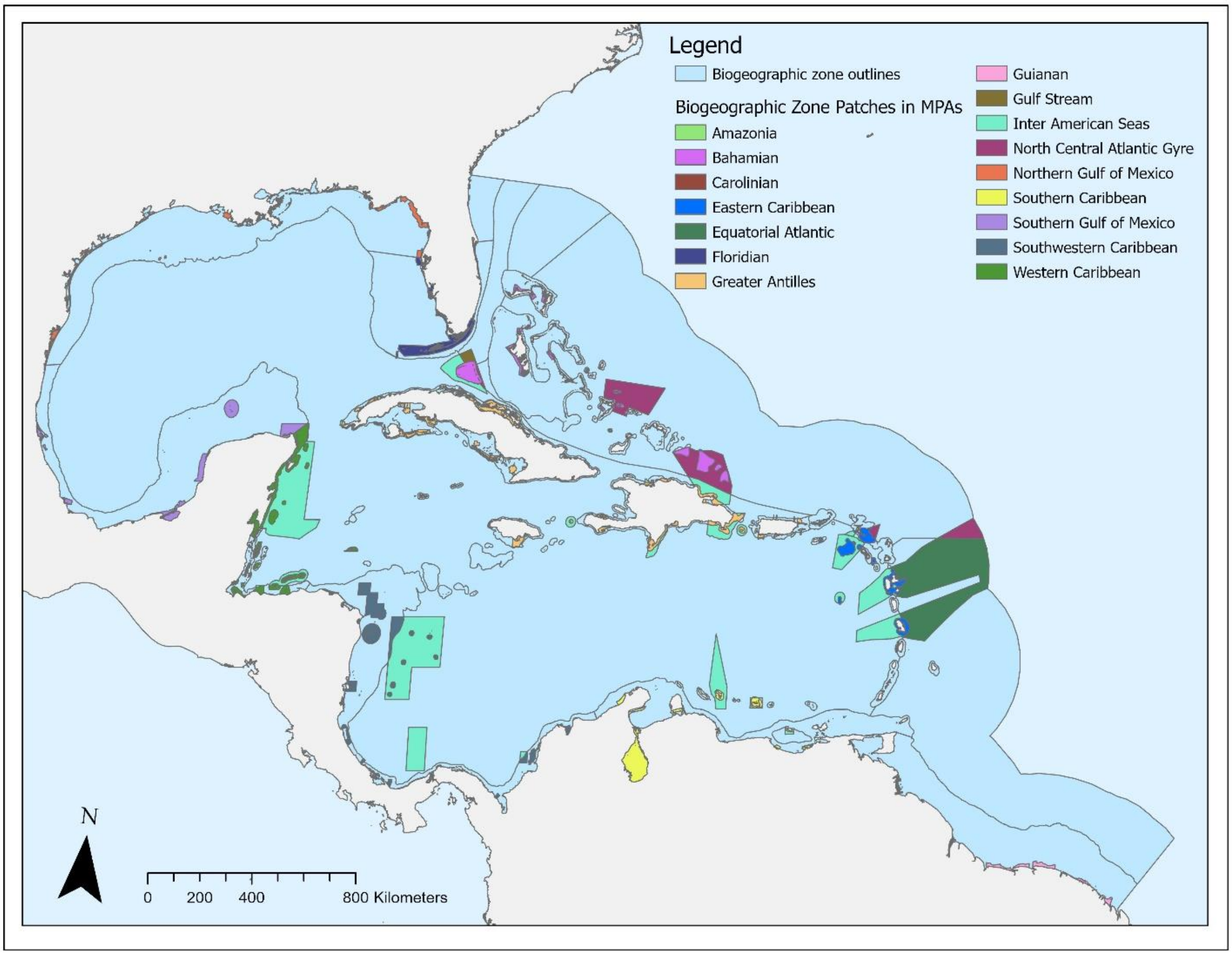

Figure 13. Patches of biogeographic zones within MPAs. Patches of the same color in different MPA footprints represent replicates of biogeographic zone patches. Calculations were done in an equal-area projection, but the figure is displayed in the Robinson projection to reduce distortion. Data sources: Flanders Marine Institute (2019); NOAA (2017); UNEP-WCMC & IUCN (2021d); The Nature Conservancy (2012).

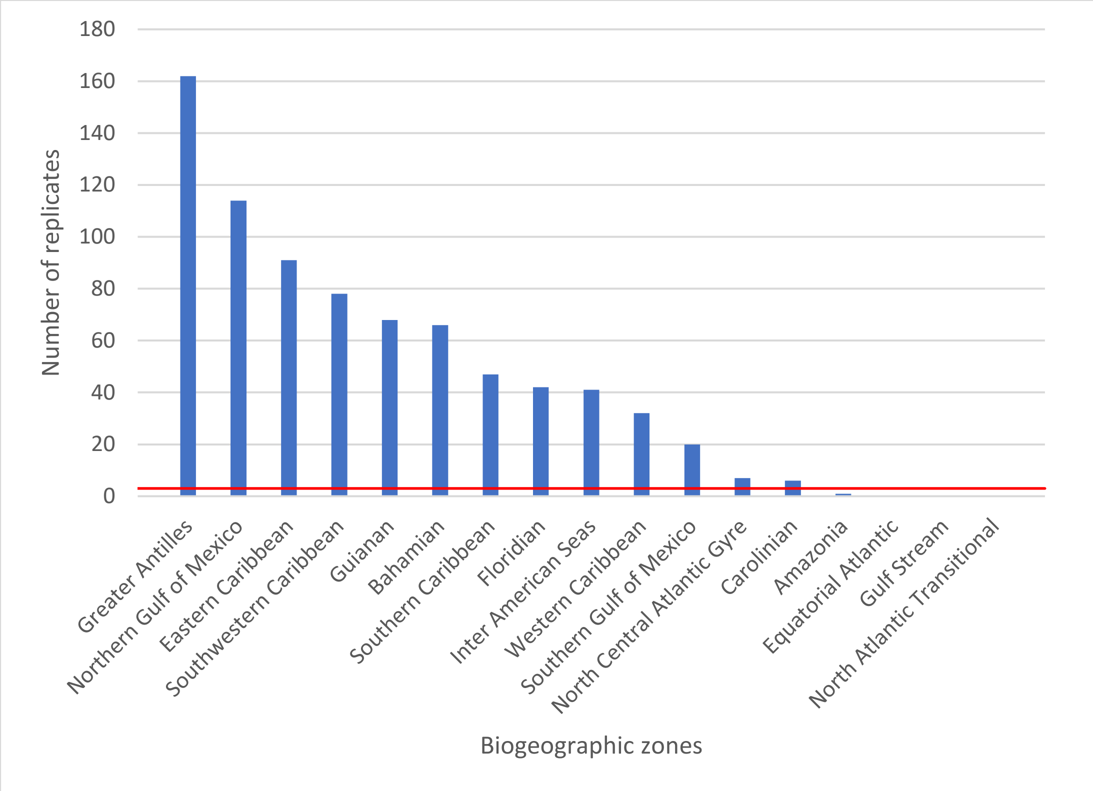

Figure 14. The number of replicates of biogeographic zone patches contained within MPAs. The target (red line) is 3 replicates (4 patches) of each biogeographic zone.

4.2.2 Replication Biogeographic Zones in No-Take Areas

The number of no-take MPA footprints containing at least one biogeographic zone patch was calculated. The target was 3 replicates (4 patches) of each biogeographic zone. Figure 15 shows a map of the biogeographic zone patches contained within no-take MPAs. As displayed in Figure 16, less than half (7 out of 17) of the biogeographic zones met the target number of replicates in no-take MPAs and 9 zones were not represented at all within no-take zones.

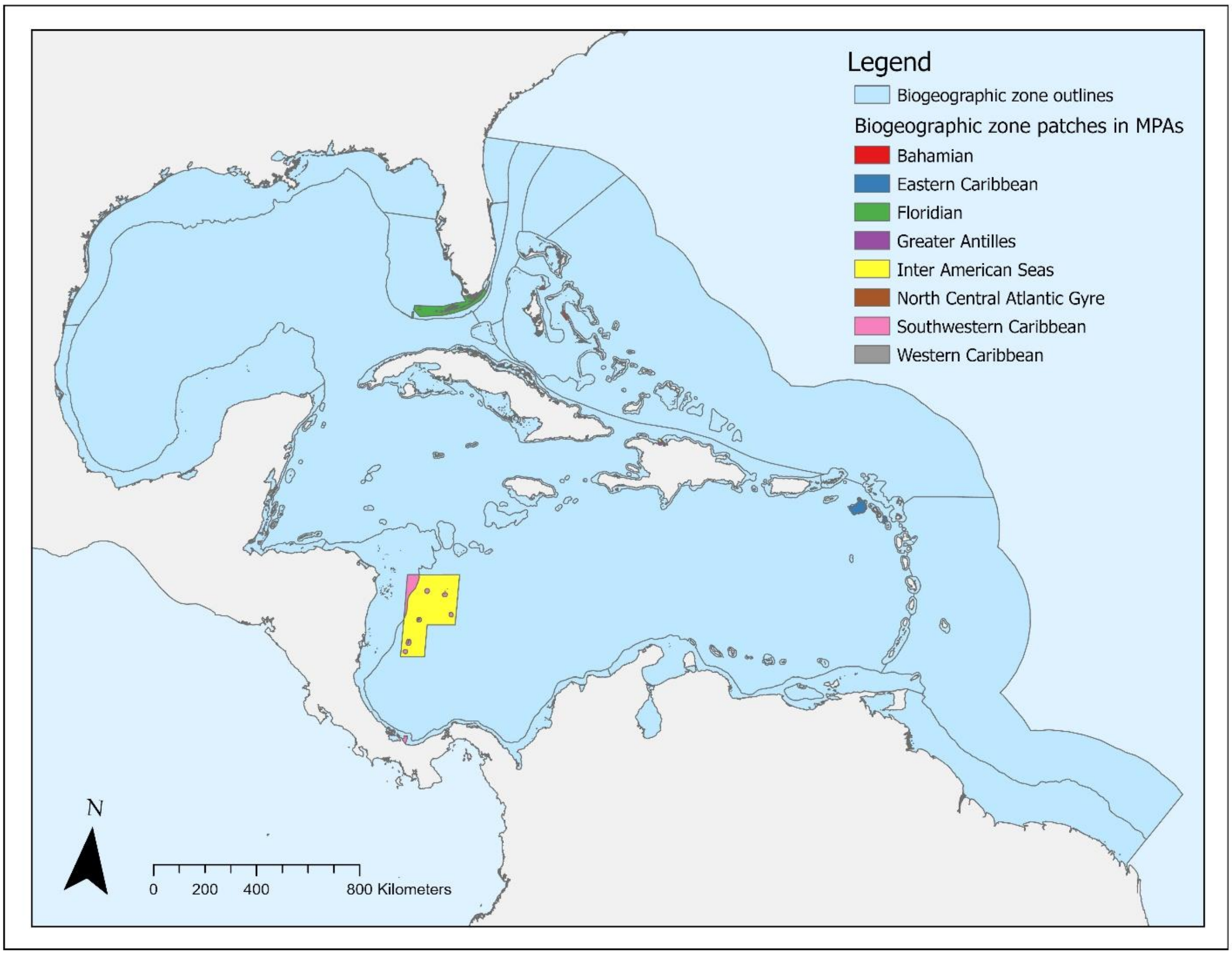

Figure 15. Patches of biogeographic zones within no-take MPAs. Patches of the same color in different no-take MPA footprints represent replicates of biogeographic zone patches. Calculations were done in an equal-area projection, but the figure is displayed in the Robinson projection to reduce distortion. Data sources: Flanders Marine Institute (2019); NOAA (2017); UNEP-WCMC & IUCN (2021d); The Nature Conservancy (2012).

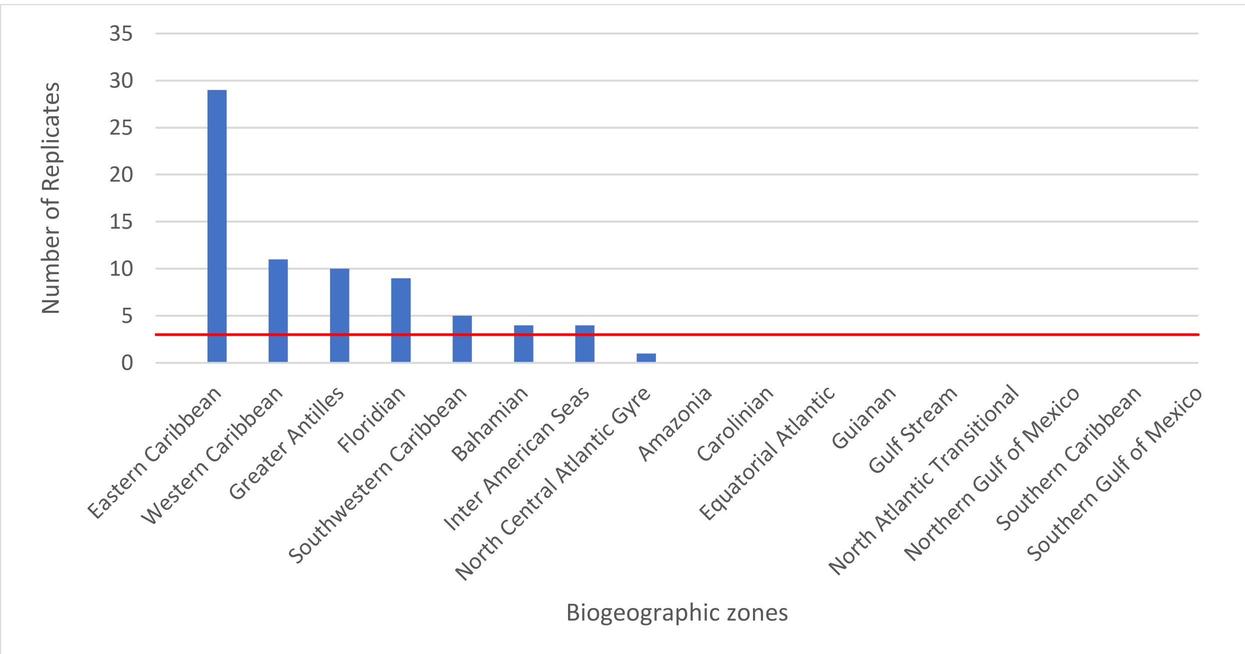

Figure 16. The number of replicates of biogeographic zone patches contained within no-take MPAs. The target (red line) is 3 replicates (4 patches) of each biogeographic zone.

4.2.3 Replication of Habitats

The number of MPA footprints containing at least one habitat patch was calculated. The target was 3 replicates (4 patches) of each habitat type. Figure 17 shows a map of the habitat patches covered by the MPAs. The number of replicates of each habitat type is displayed in Figure 18. The number of replicates of each habitat type ranged from 6 (deep hard) to 474 (shallow soft), thus all habitat types exceeded the target. The habitats with the lowest replication within MPAs were the two deep habitats, deep hard (6 replicates) and deep soft (17 replicates).

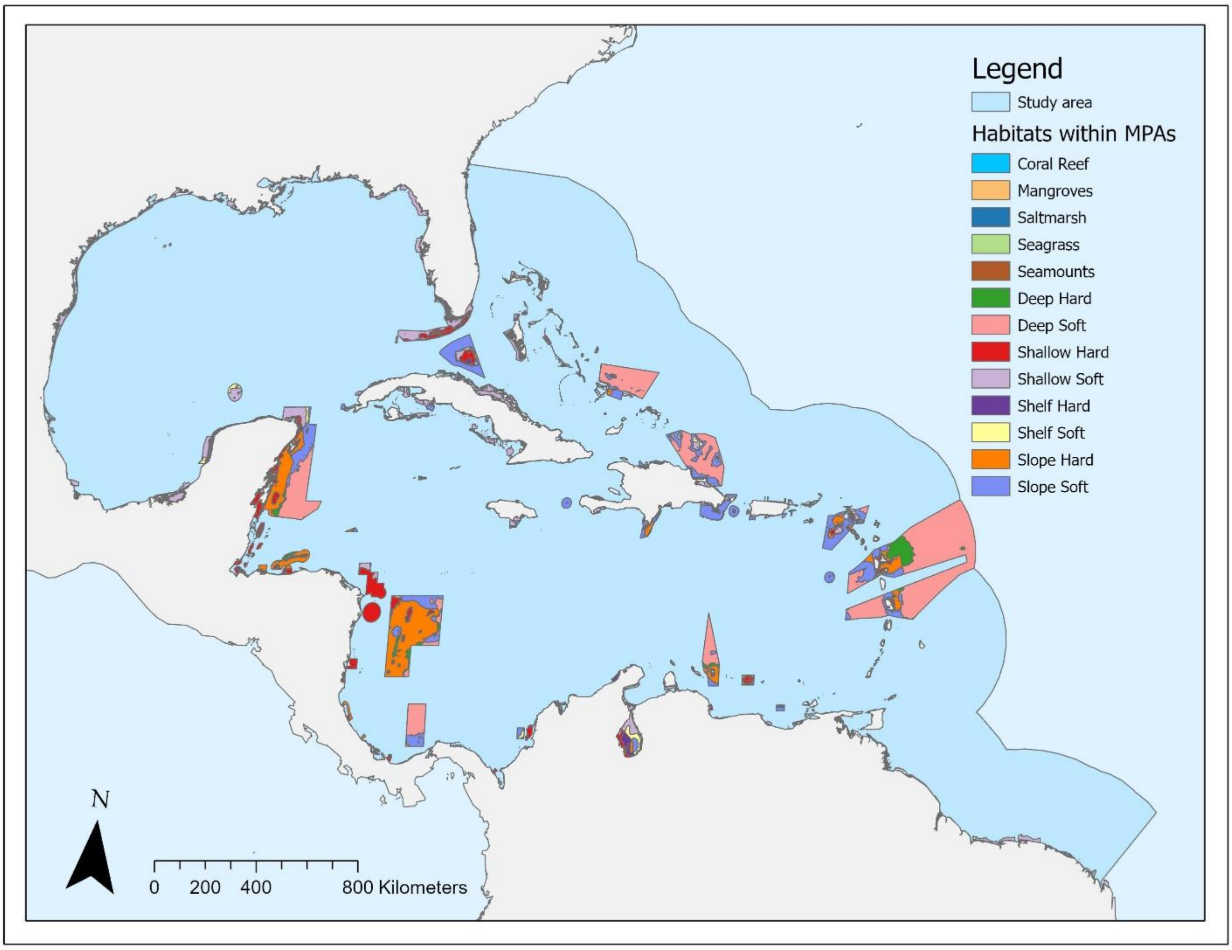

Figure 17. Patches of habitats within MPAs. Patches of the same color in different MPA footprints represent replicates of habitat type patches. Calculations were done in an equal-area projection, but the figure is displayed in the Robinson projection to reduce distortion. Data sources: Flanders Marine Institute (2019); NOAA (2017); UNEP-WCMC & IUCN (2021d); Halpern et al. (2019); Mcowen et al. (2017); UNEP-WCMC & Short (2021); UNEP-WCMC et al. (2021); Bunting et al. (2018); Yesson et al. (2011).

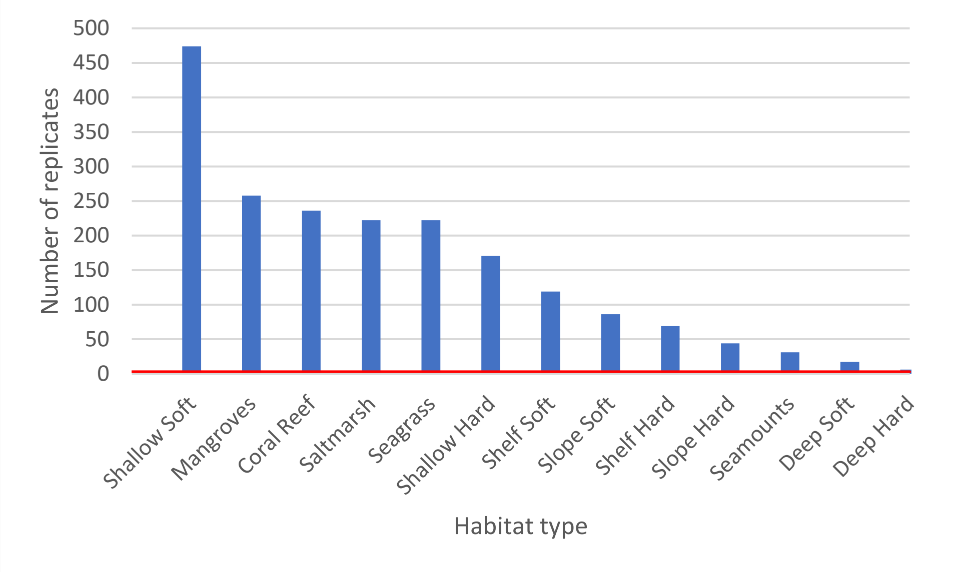

Figure 18. The number of replicates of habitat patches contained within MPAs. The target (red line) is 3 replicates (4 patches) of each habitat type.

4.2.4 Replication of Habitats in No-Take Areas

The number of no-take MPA footprints containing at least one habitat patch was calculated. The target was 3 replicates (4 patches) of each habitat type. Figure 19 shows a map of the habitat patches contained within no-take MPAs. Nine of the 13 habitat types exceeded the target, with coral reefs having the most replicate patches (56) (Figure 20). Two of the habitat types, salt marsh and deep soft, were not represented at all within no-take MPAs (Figure 20).

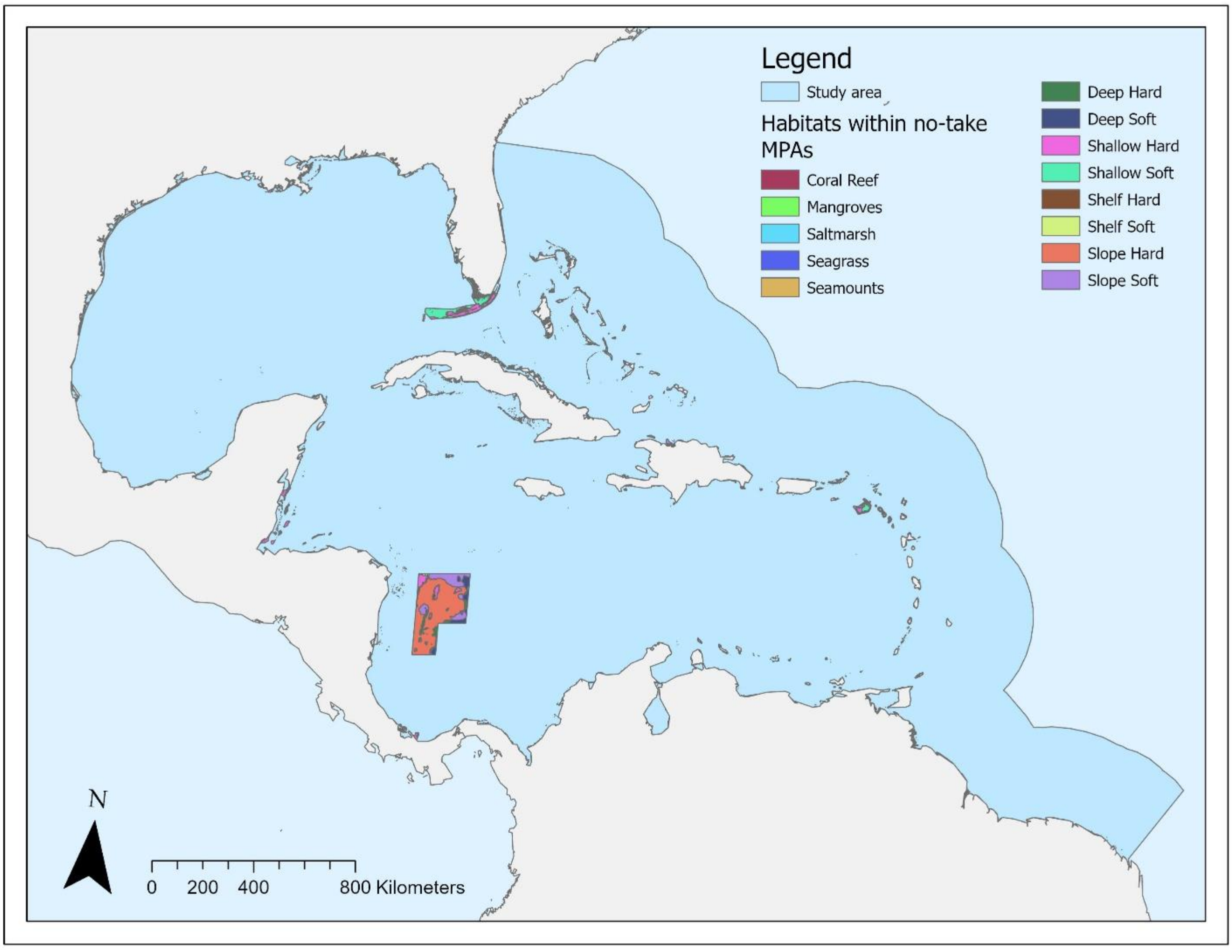

Figure 19. Patches of habitats within no-take MPAs. Patches of the same color in different MPA footprints represent replicates of habitat type patches. Calculations were done in an equal-area projection, but the figure is displayed in the Robinson projection to reduce distortion. Data sources: Flanders Marine Institute (2019); NOAA (2017); UNEP-WCMC & IUCN (2021d); Halpern et al. (2019); Mcowen et al. (2017); UNEP-WCMC & Short (2021); UNEP-WCMC et al. (2021); Bunting et al. (2018); Yesson et al. (2011).

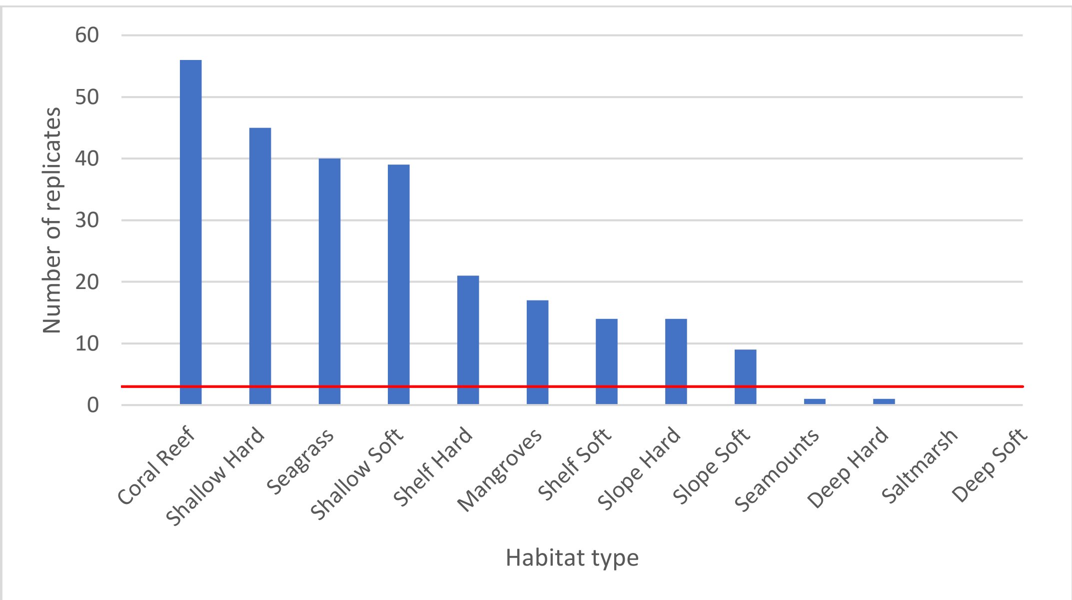

Figure 20. The number of replicates of habitat patches contained within no-take MPAs. The target (red line) is 3 replicates (4 patches) of each habitat type.

4.3 Connectivity

4.3.1 Distance Between MPAs

The distance between MPA footprints was calculated as a measure of connectivity. For this test, an MPA was defined as connected if it was within 20 km of another MPA. The target was that 75% of MPAs should be within 20 km of another MPA. This test was only conducted at the regional level. Of the 738 MPA footprints in the study region above the minimum size (.24 km^2), 672 were connected, which is 91.06%. Thus, the target was exceeded. Figure 21 is a visualization of the results of this test.

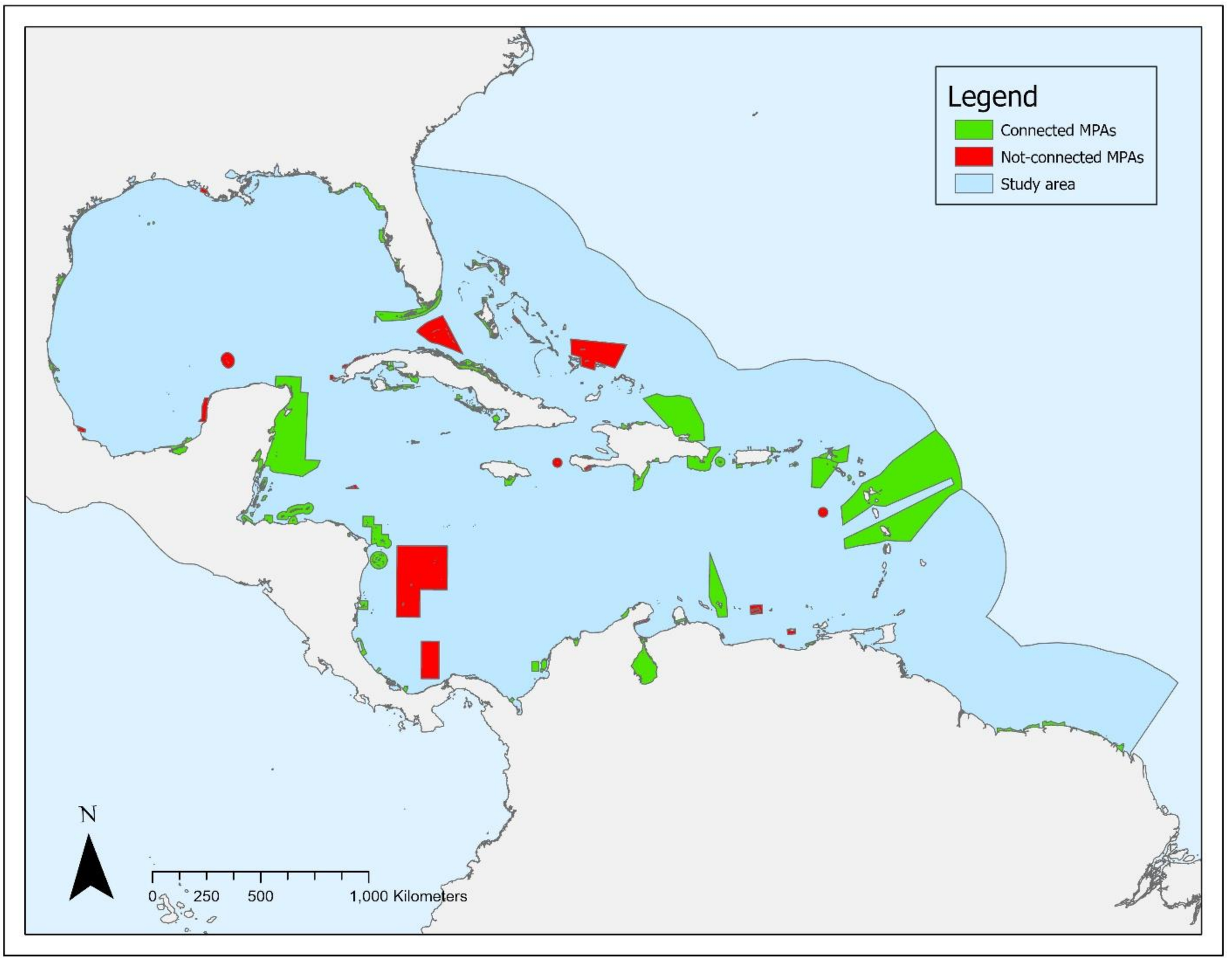

Figure 21. Connected and not connected MPA footprints in the Wider Caribbean Region. The green polygons (connected MPAs) are MPA footprints that are within 20 km of another MPA footprint. The red polygons (not-connected MPAs) are MPA footprints that are more than 20 km from another MPA footprint. Distance calculations were done in the Azimuthal equidistant projection displayed here. Data sources: Flanders Marine Institute (2019); NOAA (2017); UNEP-WCMC & IUCN (2021d).

4.3.2 Distance Between No-Take MPAs

The distance between no-take MPA footprints was calculated as a measure of connectivity. For this test, a no-take MPA was defined as connected if it was within 20 km of another no-take MPA. The target was that 75% of no-take MPAs should be within 20 km of another no-take MPA. This test was only conducted at the regional level. There were only 74 no-take MPA footprints above the minimum size (.24 km^2). Of those, 61 were within 20 km of another no-take MPA footprint. Thus, 82.43% of the no-take MPAs were connected. Thus, the target was exceeded. Figure 22 is a visualization of the results of this test.

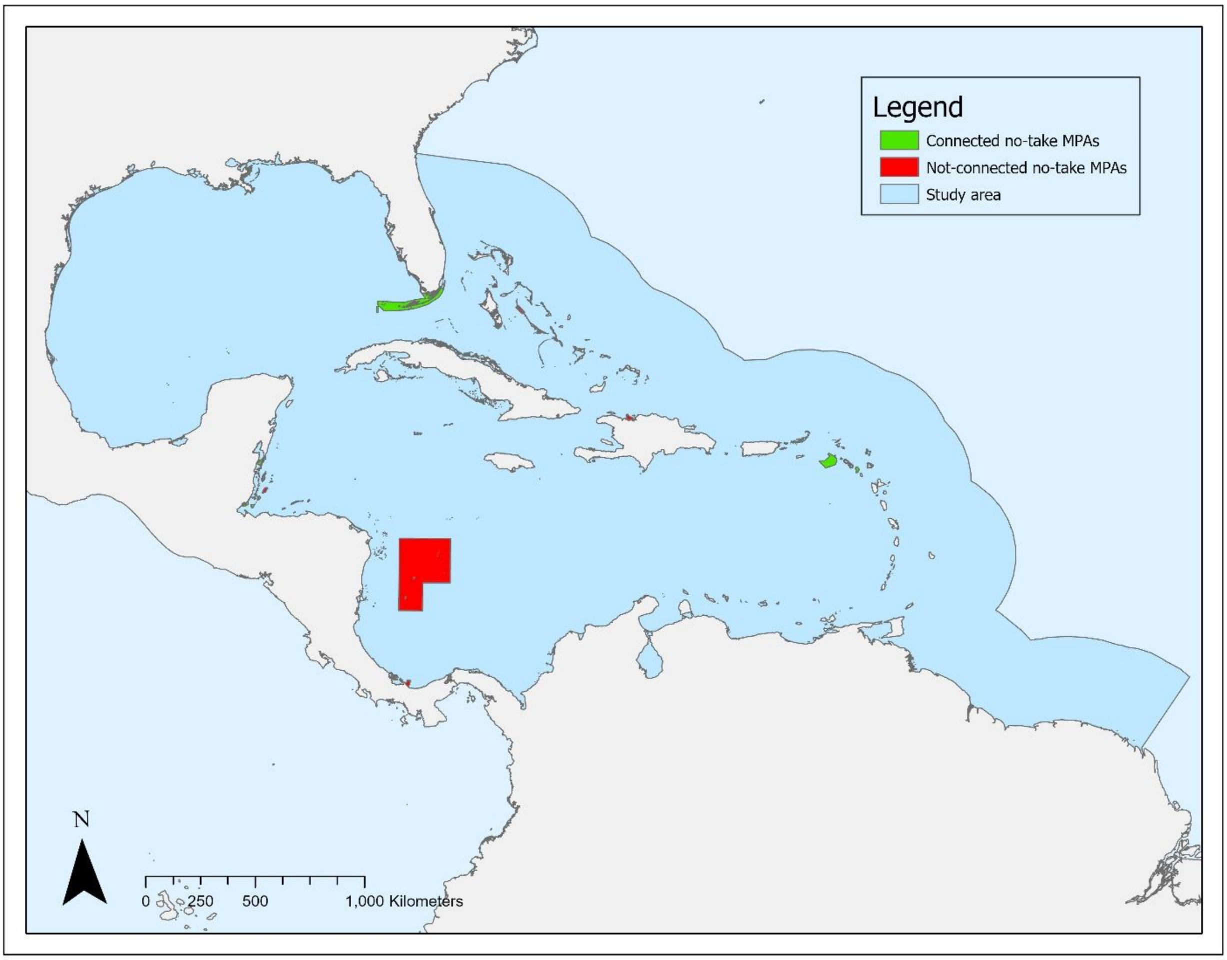

Figure 22. Connected and not connected no-take MPA footprints in the Wider Caribbean Region. The green polygons (connected MPAs) are no-take MPA footprints that are within 20 km of another no-take MPA footprint. The red polygons (not connected MPAs) are no-take MPA footprints that are more than 20 km from another no-take MPA footprint. Distance calculations were done in the Azimuthal equidistant projection displayed here. Data sources: Flanders Marine Institute (2019); NOAA (2017); UNEP-WCMC & IUCN (2021d).

4.3.3 Distance Between Protected Habitats

Connectivity of habitats was measured as the distance between MPA footprints containing the same habitat type. To pass this test, 75% of MPA footprints containing a habitat patch above a minimum size (.24 km^2) must be within 80 km of another MPA footprint containing a patch of the same habitat above the minimum size. The percent of connected MPAs for each habitat type can be seen in Figure 23. Eight of the thirteen habitats passed this test. The habitat types with the lowest percent connectivity, deep hard (0% connected) and deep soft (44.44% connected), were also the habitats with the fewest number of MPAs containing patches of those habitats (7 and 18 MPAs, respectively).

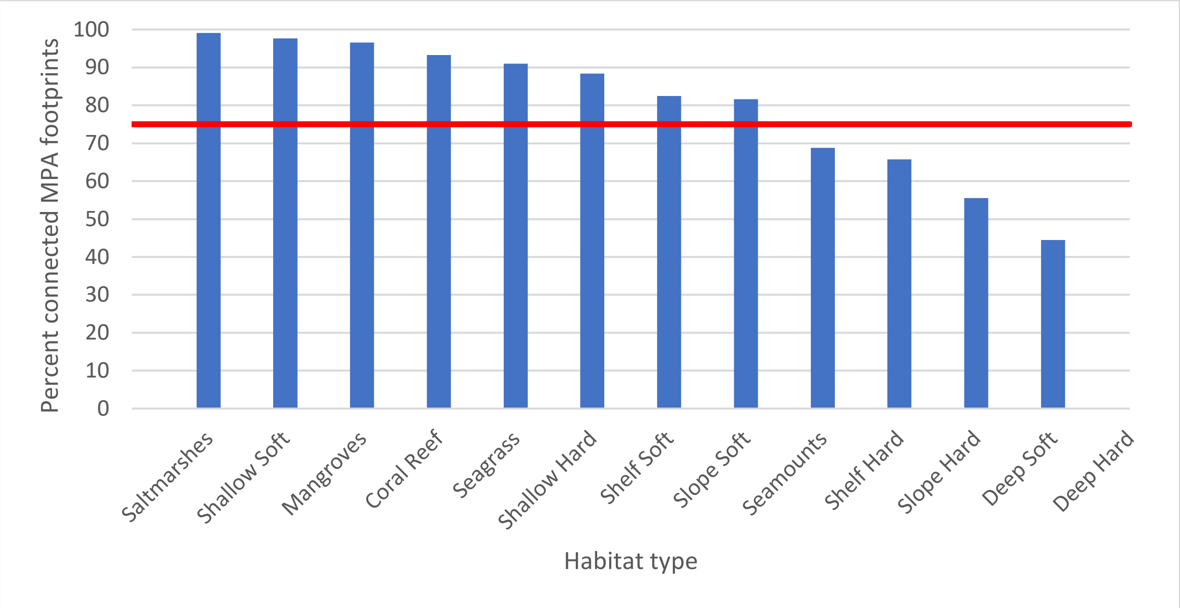

Figure 23. For each habitat type, the percent of MPA footprints containing patches of a particular habitat that are connected by less than 80 km to another MPA containing patches of the same habitat was calculated. The threshold, shown by the red line, was that 75% of MPAs containing a particular habitat type should be connected.

4.4 Adequacy

4.4.1 Size of MPAs

The adequacy of the size of MPAs was determined by comparing the sizes of MPAs to a minimum threshold size. To pass this test, 75% of MPAs at the regional and subregional level must be larger than 5 km^2. A frequency distribution of the sizes of MPAs in the Wider Caribbean Region was generated, following the bin size classification recommendation of Agnesi et al. (2017) (Figure 24). As can be seen in Figure 24, more MPAs were in the smallest size class (<5 km^2) than any other size class. The percent of MPAs larger than 5 km^2 was calculated for each subregion and the entire region, and the results are displayed in Figure 25. Only two subregions (Southwestern Caribbean and Western Caribbean) reached the target of 75% of MPAs larger than 5 km^2. The region with the lowest percentage of MPAs greater than 5 km^2 was Eastern Caribbean, with 37.57% MPAs larger than 5 km^2. In the Wider Caribbean Region, 63.0% of MPAs are larger than 5 km^2, thus the target was not reached at the regional level.

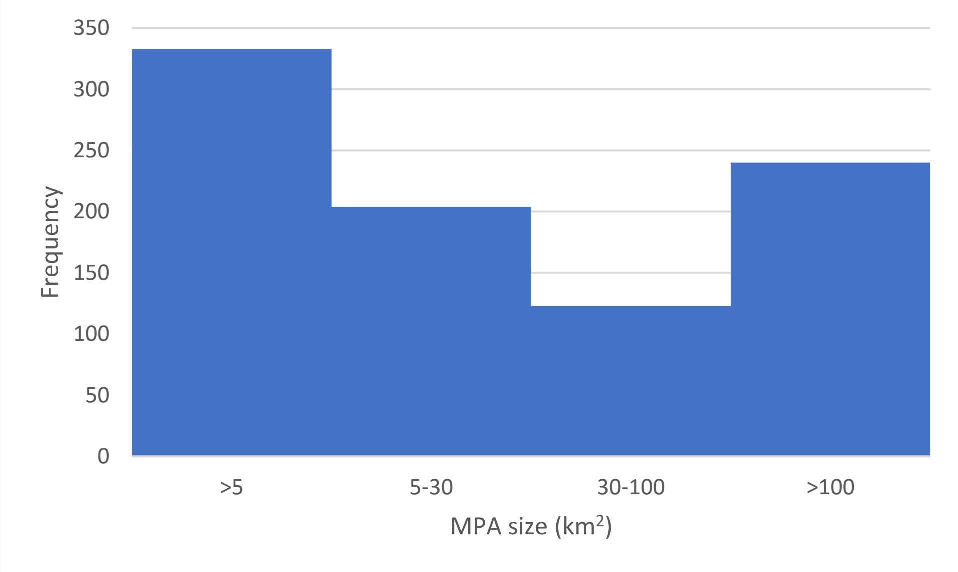

Figure 24. A frequency distribution of the sizes of MPAs in the Wider Caribbean Region. N=900.

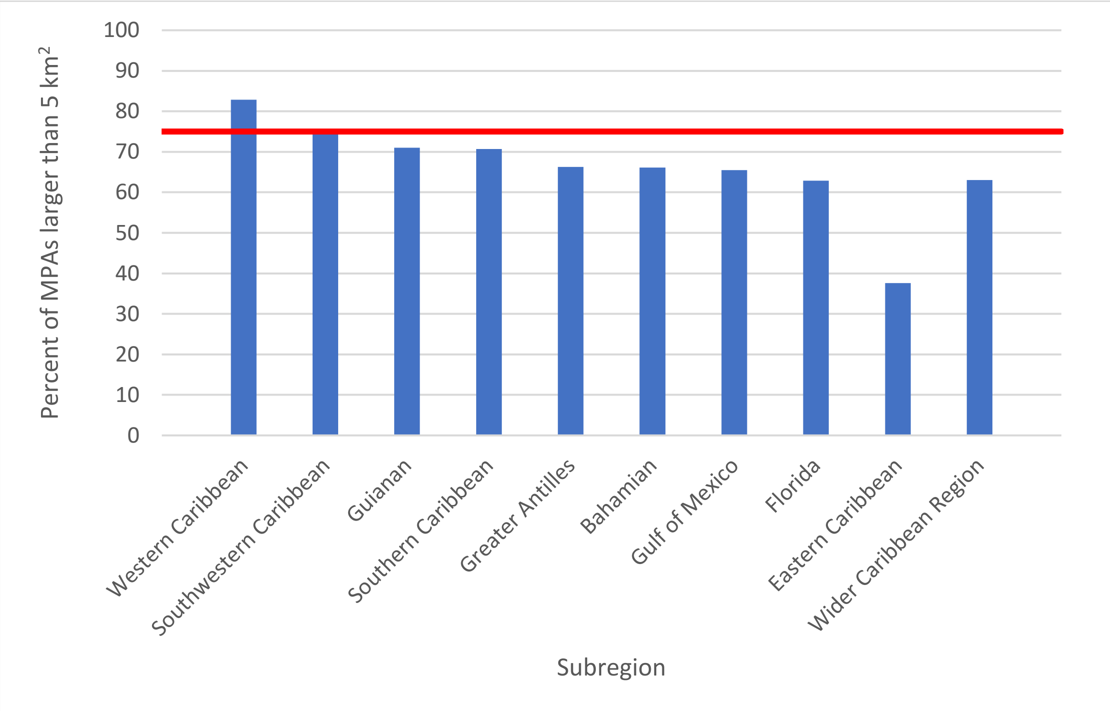

Figure 25. The percent of MPAs larger than 5 km^2 in each subregion and in the Wider Caribbean Region. The target (red line) is 75% of MPAs larger than 5 km^2.

4.4.2 Level of Protection

The percent of MPA that are designated as no-take MPAs was calculated on the subregional and regional level. This test was passed if 30% of the MPAs in the subregion were designated as no-take. Not a single subregion met this target (Figure 26). The Eastern Caribbean subregion had the highest percent of no-take MPAs (17.68%) and three of the subregions did not contain a single no-take MPA.

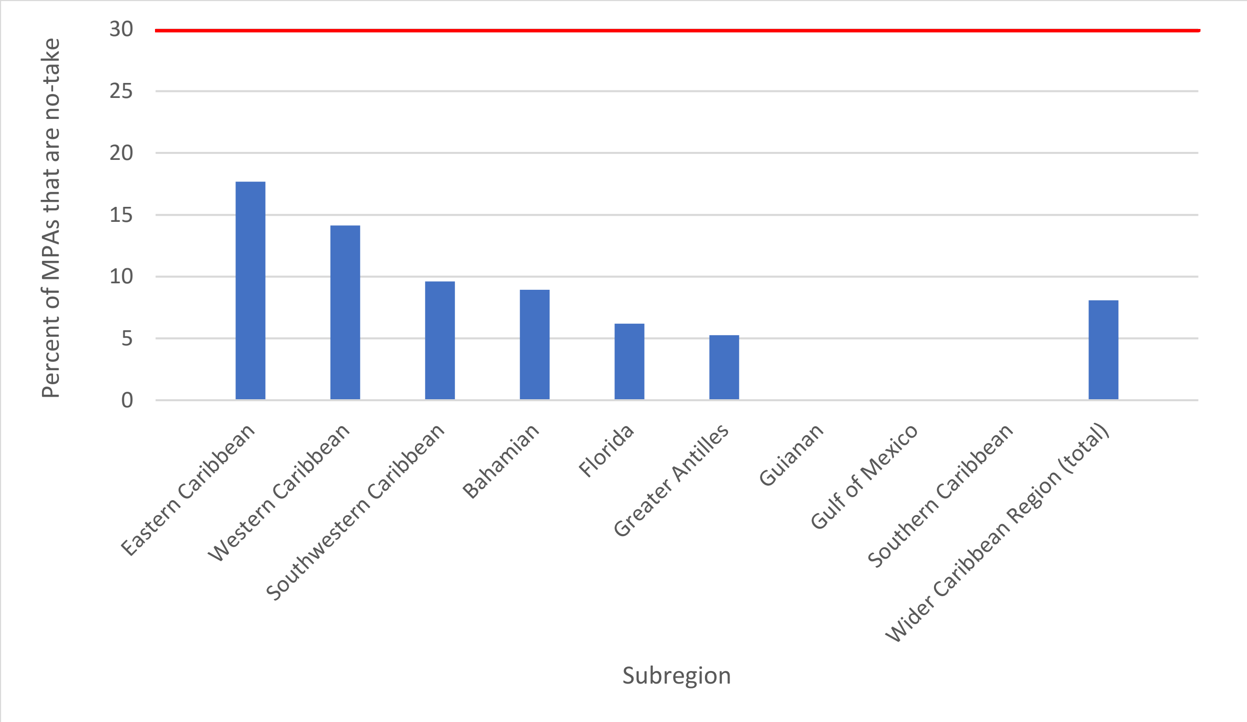

Figure 26. The percent of MPAs that are designated as no-take in each subregion and in the Wider Caribbean Region. The target (red line) is 30% of MPAs should be designated as no-take.

4.4.3 Human Impact

Measuring human impact within MPAs was calculated as the percent of MPA area within the least impacted marine aeras. This was measured at the subregional and regional level. The test was passed if 75% of MPA area in the region or subregion was within the least impacted marine areas. First a map was made of the most and least impacted areas, as described in the methodology (Figure 27). Then, the MPAs were overlaid with the human impact map, resulting in a map showing MPA areas that are highly impacted and less impacted (Figure 28). The percent of the MPA area that is in low impact zones was calculated for each subregion and the entire region. Five of the nine subregions passed with test, with more than 75% of MPA areas in less impacted areas (Figure 29). The subregion with the least amount of MPA area in low impact zones was the Eastern Caribbean subregion (15.05%) and the subregion with the most MPA area in low impact zones was the Bahamian subregion (99.76%). When analyzed on a regional level, 62.73% if the MPAs in the region are in low impact zones, thus the test was not passed at the regional level.

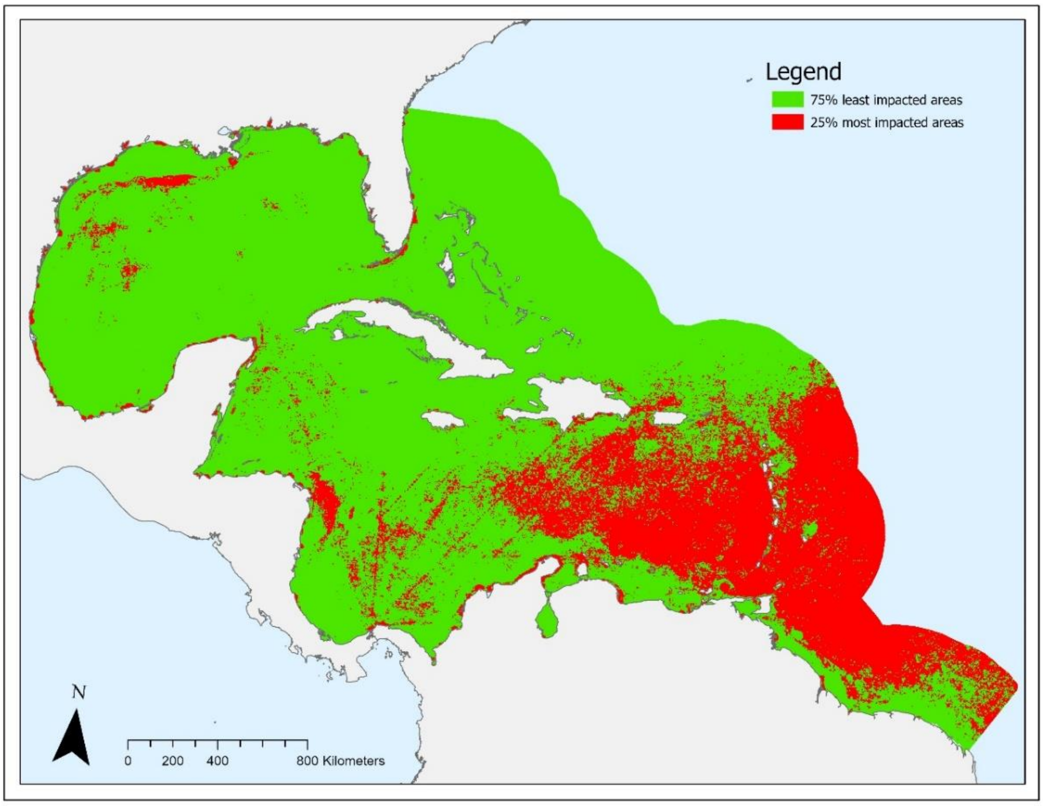

Figure 27. The cumulative human impact data (Halpern et al. 2019) was reclassified as the 75% least impacted areas (green) and the 25% most impacted areas (red) in the study region. Data sources: Flanders Marine Institute (2019); NOAA (2017); Halpern et al. (2019).

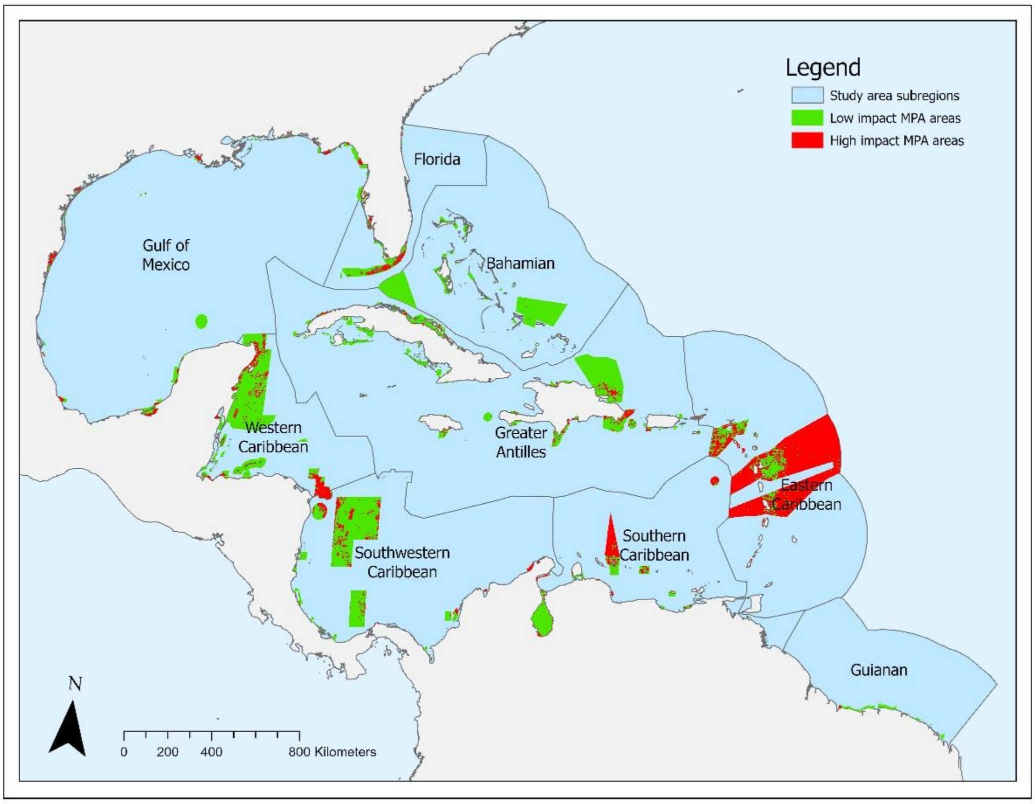

Figure 28. Human impact in MPAs. MPA footprint areas are classified as either residing in high or low impact areas. Red indicates high impact areas within MPAs and green areas indicate low impact areas within MPAs. Data sources: Flanders Marine Institute (2019); NOAA (2017); UNEP-WCMC & IUCN (2021d); Halpern et al. (2019).

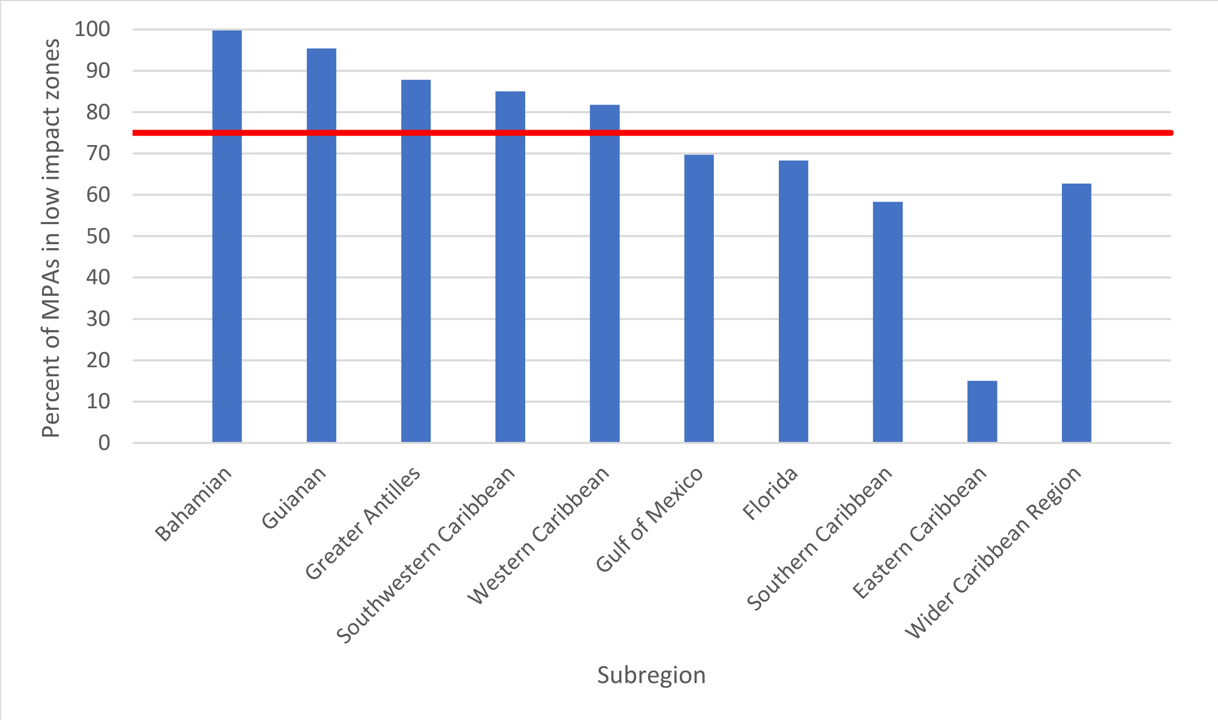

Figure 29. The percent of MPA footprint areas within low impact zones was calculated for each subregion and for the entire Wider Caribbean Region. The target (red line) is 75% of MPA areas in low impact zones.

4.5 Aggregating the Criteria

The results of the tests were aggregated as described in section 3.6. First, an integration table was completed for each of the four main criteria (Appendices C, D, E, and F). The integration tables were completed with the results of the tests; the target levels; and uncertainty rankings for data, target, and method. The rationale for the uncertainty rankings and their corresponding values are in Appendix B.

Each main criterion was given a final score, calculated from its respective integration table. The final score was translated to a likelihood of ecological coherence achievement, using Table 6. Table 7 shows the final scores and likelihood of ecological coherence for each criterion. Based on the integration tables, ecological coherence is only likely to be achieved in representativity. For replicability and connectivity, ecological coherence is unlikely to be achieved. Adequacy had the lowest score, indicating that ecological coherence is very unlikely to be achieved for that criterion.

Table 7. The final main criterion scores, as calculated from the integration tables. The final scores were then translated to a likelihood of ecological coherence being achieved.

Main Criterion	**Final main criterion score**	**Likelihood of ecological coherence being achieved**	**Ecological coherence of the Wider Caribbean Region MPA network**
Representativity	1.13	Likely	It is very unlikely that ecological coherence is reached
Replicability	0.94	Unlikely	
Connectivity	0.68	Unlikely	
Adequacy	0.48	Very unlikely	

The final outcome of ecological coherence was determined based on the final scores of each main criterion. As this methodology uses the one-out-all-out principle, the criterion with the lowest score determined the final outcome. Adequacy had the lowest score (.48), which translates to be very unlikely to be ecologically coherent, so this was applied to the entire assessment. Thus, the Wider Caribbean Region MPA network is ***very unlikely*** to have reached ecological coherence.

Chapter 5: Discussion

Until this study, there was very little information on the status of the Caribbean MPA network at the regional level. The most similar previous work was a Caribbean-wide survey of marine reserves by Appeldoorn and Lindeman (2003) and a study on the current status of MPAs in Latin America and the Caribbean by Guarderas et al. (2008). This assessment is the first ecological coherence assessment to be conducted in the region.

5.1 Key Findings of the Four Main Criteria

5.1.1 Representativity and Replicability

Of the four main criteria, representativity had the highest likelihood of having achieved ecological coherence. Despite this achievement, many representativity thresholds were not met. In the entire region and most subregions, the basic test of 10% MPA coverage was not met. This target is based on Aichi Target 11, but there was also a Caribbean-specific target signed by eleven countries and territories to protect 20% of nearshore marine environments by 2020 (Caribbean Challenge Initiative 2020), as well as the more ambitious target of 30% protection by 2030 in the zero draft of the post-2020 Global Biodiversity Framework. This assessment did not analyze nearshore protection specifically, so it cannot be directly compared to the Caribbean-specific target, but since the basic 10% target was not met, there is still a long way to go to reach the more ambitious proposed 30% target.

Ecological coherence in terms of replicability was unlikely to have been achieved. In fact, meaningful replicability is likely even lower than it appears in the results for three reasons. First, the scale of the assessment was likely too large for the low target of 3 replicates (see section 5.4.2). Second, the habitat classification level may have been too broad for the target. Most ecological coherence assessments of European waters used European Nature Information System (EUNIS) level 3 habitats (OSPAR 2017; OSPAR 2013; HELCOM 2016; Foster et al. 2017), which is a finer scale of habitat classification than is available in the Caribbean. Had finer scale habitat data been available, it likely would have resulted in fewer replicates. Third, the tests do not take actual protection of features into account. As such, a feature may be counted as replicated in multiple MPAs but may not be protected in any of them (see section 5.4.1). For this reason, the replicability tests for no-take MPAs result in more meaningful indications of replicability because it can be assumed that features within the no-take areas are being protected. The fact that so many no-take areas do not meet the already low threshold of 3 replicates is an indication that focus should be put on creating more no-take MPAs that contain those features that are not sufficiently replicated.

Habitats appear to be well represented in the network. In general, a greater proportion of less common habitats should be protected compared to the proportion of protected common habitats (Johnson et al. 2014). This was supported by the results, as a higher percentage of less common habitats are contained by MPAs compared to more common habitats. In fact, the habitats with the lowest proportion of MPA coverage are the habitats with the largest area. Additionally, some particularly ecologically important habitats in the region (mangroves, coral reef, seagrass, and saltmarshes) were among those with the highest proportion covered by MPAs. This tendency for MPAs in the Caribbean to primarily protect coral reefs, mangroves and seagrass habitats was also confirmed by Appeldoorn and Lindeman (2003) and Geoghegan et al. (2001). Appeldoorn and Lindeman (2003) noted that this left other important habitats insufficiently represented. As well as the most represented habitat, coral reefs were also the most replicated habitat. This finding was also supported by Appeldoorn and Lindeman (2003), who found that the current MPA network provides "some preliminary degree of replication" only among the reef and reef-associated habitats. This focus on coral reef protection is understandable given the economic and ecological importance of reefs and the anthropogenic stress on them (Appeldoorn and Lindeman 2003), but conservation should also target other habitats.

Appeldoorn and Lindeman (2003) reported a distinct lack of no-take MPAs protecting soft and hard bottom slope and deep habitats. This assessment similarly found that soft and hard deep and soft slope habitats were among the least represented habitats. Deep habitats in the Caribbean should be prioritized more for protection, as deep-water environments are one of the largest reservoirs of biodiversity on Earth, containing unique ecosystems and species not found elsewhere on the planet (UNEP 2006; Tyler 2003). MPAs aimed at protecting deep habitats should protect the water column above the seafloor, as well as the seafloor habitat. Species that live in the water column of deep seas are important for shaping deep sea ecosystems (O'Leary and Roberts 2017) and thus should be protected for their effect on seafloor habitats, as well as for their own right. For example, commercial whaling not only causes a decline of whales, but also results in habitat loss, nutrient loss, and a change in the food web structure of the deep-sea ecosystem (O'Leary and Roberts 2017). The reverse is also true, with features of the seafloor effecting the species living above it, such as seamounts creating upwellings that push nutrient rich water upwards (Buchs et al. 2015).

5.1.2 Connectivity and Adequacy

Despite both the MPA connectivity and no-take MPA connectivity tests exceeding the threshold, the connectivity criterion was still unlikely to have reached ecological coherence. This was in large part due to the high uncertainty in the method (see Appendix B and section 5.4.3). It is initially surprising that the no-take MPA connectivity test passed the threshold, considering the very low number of no-take MPAs in the region. The high connectivity of the no-take MPAs is explained by the highly clustered spatial distribution of the no-take MPAs found mainly in the Eastern Caribbean (Mesoamerica, specifically) and Western Caribbean subregions. Within those clusters the no-take MPAs are connected, but the no-take MPAs are not well distributed throughout the region, as evidenced by the fact that three of the subregions do not contain a single no-take MPA. Similarly, Appeldoorn and Lindeman (2003) concluded that the spatial distribution of current no-take MPAs is insufficiently connected, with the possible exception of Mesoamerica. This uneven distribution of MPAs in the Caribbean was also noted by Guarderas et al. (2008), who attributed it to different degrees of organizational capacity among the countries, differing degrees of knowledge of marine systems throughout the region, a focus on protecting conservation hotspots, and marine resource use competing with conservation objectives in particular areas.

Of the four main criteria, adequacy was the least likely to have reached ecological coherence. Throughout the entire region, there should be larger MPAs and more no-take MPAs, because nearly all the subregions failed the test for MPA size, about half of the subregions failed the test for human impact, and *every single* subregion failed the test for amount of no-take MPAs. Appeldoorn and Lindeman (2003) suggest that the low coverage of no-take MPAs in the region is due to the low prioritization of marine resources in proportion to their economic importance, as well as social, economic, and biological obstacles to establishing MPAs. The adequacy results also supported Appeldoorn and Lindeman's (2003) findings that most MPAs in the Caribbean are of insufficient size to protect all life stages of species. Studies by Kendall et al. (2003) and Appeldoorn et al. (2003) found that some reef fish in the Caribbean forage out between 0.78 – 3.14 km^2 daily. Almost a third (32%) of MPAs in the region are smaller than 3.5 km^2, suggesting that many of the MPAs are not even large enough to include the daily foraging range of reef species. Other researchers are also calling for larger MPAs in the Caribbean, as a recent letter in *Science* said, establishing larger MPAs in the Caribbean "is both an opportunity and a necessity" (Gallagher et al. 2020).

Overall, the novel methodology for testing human impact introduced in this assessment was successful, but the results should be interpreted cautiously. This assessment emulated the overall goal used by Wolters et al. (2015) – that a high proportion of MPA area should be unaffected by human pressures. However, this goal does not consider that MPAs may be strategically established in areas with high human impact with the express purpose of reducing human pressures over time. This test does not reflect trends in human pressures in relation to MPAs, although such a test would provide valuable information. The test as it is now could potentially discourage the establishment of MPAs where zones of high biodiversity importance overlap with zones of high human impact, which may be the areas in most need of protection.

5.2 Geographic Differences Within the Wider Caribbean Region and Recommendations

A visualization of the number of tests passed in different geographic locations highlights major gaps in the Wider Caribbean Region MPA network (Figure 30). This map was created by combining the results of the eight tests that were assessed on the subregional or biogeographic zone level (Table 8). For each of those tests, the subregion or biogeographic zone was categorized as having passed or failed the test. The information was then compiled and displayed to show a comparison of the areas that passed and failed the most tests. This map does not demonstrate where ecological coherence has or has not been reached, as it does not contain data from all the tests. Nor is it meant to be a guideline for prioritizing new MPAs, as it does not include other factors that would be important for prioritization, such as economic or socioeconomic factors.

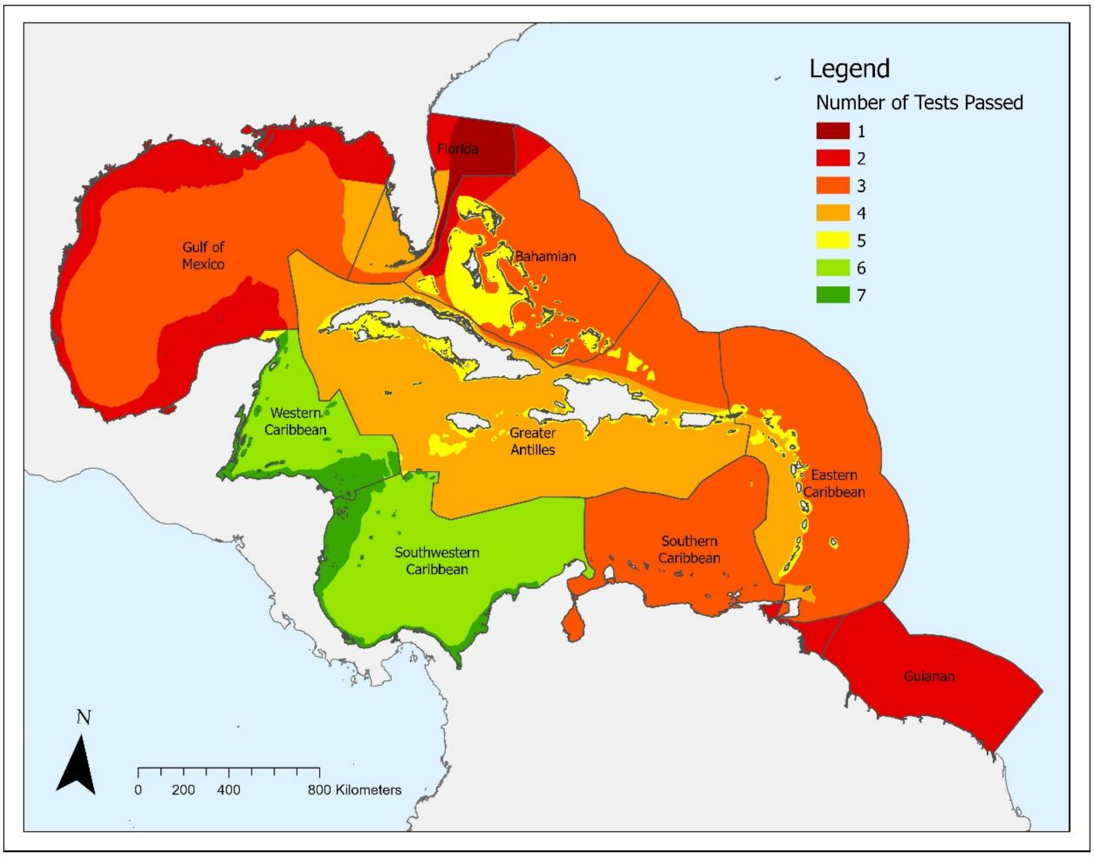

Figure 30. A geographic representation of the number of tests where the threshold was exceeded by the subregion or biogeographic zone. This map only includes data from the eight tests that were assessed on the subregional or biogeographic level (Table 8). Data sources: Flanders Marine Institute (2019); NOAA (2017); UNEP-WCMC & IUCN (2021d); Halpern et al. (2019); The Nature Conservancy (2012); BirdLife International (2021).

Table 8. The tests included in Figure 30. Only tests assessed at the subregional and biogeographic zone level were included.

Main Criteria	**Test**	**Level of Assessment**
Representativity	General coverage	Subregional
Representativity	Coverage of biogeographic zones	Biogeographic zones
Representativity	Coverage of ecologically important areas	Subregional
Replication	Replication of biogeographic zones	Biogeographic zones
Replication	Replication of biogeographic zones in no-take MPAs	Biogeographic zones
Adequacy	Size of MPAs	Subregional
Adequacy	Level of protection	Subregional
Adequacy	Human impact	Subregional

As is clear in Figure 30, the areas that passed the most tests are within the Western Caribbean and Southwestern Caribbean subregions. The Western Caribbean was also seen as the best example of marine protection in the region by Appeldoorn and Lindeman (2003). Appeldoorn and Lindeman (2003) found that of the entire Wider Caribbean Region, only Belize is close to achieving the recommended extent of no-take MPAs. The Western Caribbean passed the most tests partly due to the comparatively large number of no-take MPAs, as discussed above. Also, there are concerted efforts in that subregion to improve the MPA network. Belize specifically has The Belize National Protected Areas Policy and System Plan in place to ensure an effective protected area system in the country (Salas and Shal 2015). The Western Caribbean subregion is also part of the Mesoamerican Reef Programme, a subregional initiative that is working to create a "resilient network of well-managed mutually replenishing MPAs" (Wells et al. 2008). The Southwestern Caribbean subregion likely passed so many tests in part because it contains the Seaflower MPA, the second largest MPA in the Wider Caribbean Region (about 65,000 km^2). 2,330 km^2 of the Seaflower MPA is zoned as no-entry or no-take, which is only 3.59% of the total area (Wells et al. 2008). Unfortunately, because the spatial information of the no-take zones within MPAs was not available, the entirety of any MPA containing a no-take zone was included in this assessment. This led to an overall overestimation of no-take zones in all no-take associated assessments, and led to a particularly large overestimation in the case of Seaflower MPA as it is the second largest MPA in the region.

To achieve ecological coherence, the entire region must work together as a cohesive network. Ecological coherence in the Wider Caribbean Region cannot be achieved by a few subregions doing well. The results of this assessment clearly highlight some areas where significant efforts must be made to bring the region towards ecological coherence. For example, there is not a single MPA within the North Atlantic Transitional biogeographic zone, there are three subregions that do not have a single reported no-take MPA, and the Guianan subregion only has 1% of its ecologically important areas contained within MPAs.

There is great value in developing MPA networks at the regional scale using systematic and collaborative conservation planning (Wells et al. 2008), so officially developing a region wide MPA network in the Wider Caribbean Region is a worthwhile ambition. MPAs have been a major focus at the national level in the Caribbean region since the 1980s (Wells et al. 2008), but evidence of any region-wide coordination to create an ecologically coherent network is lacking. Already existing structures within the region could be strengthened to help bring the region towards ecological coherence, specifically CEP and CaMPAM. Other UNEP Regional Seas Programmes have been successful in managing regional MPA networks, notably OSPAR and HELCOM (Zbicz 2011). Thus, CEP, the UNEP Regional Seas Programme in the Caribbean, could follow the lead of OSPAR and HELCOM and be strengthened to focus on regional ecological coherence. Specifically, the SPAW Protocol can do more to strengthen the MPA network. The current contributions of SPAW to strengthening MPAs and building their capacity are provisioning grants; developing sustainable fisheries; promoting best management practices; and developing a regional MPA database (UNEP-CAR-RCU 2013; Inniss and Corbin 2019). SPAW could also focus its contributions on encouraging MPAs to be established such that they contribute to ecological coherence. CEP can also focus on strengthening the MPA network by increasing funding to CaMPAM. CaMPAM, the regional network of MPA managers created under SPAW, is active as a social network, but it faces challenges because it is understaffed, underfunded, and generally does not have the resources needed for a region of this size and with such political, lingual, and cultural diversity (Goriup 2017). Supporting such social networks can promote the development of ecologically coherent MPA networks (Wells et al. 2008).

Working to increase ecological coherence at smaller scales will also contribute to ecological coherence at the regional level. It is unusual for a single agency to have complete authority over a large MPA network, so recognizing the importance of the many institutions and groups at various scales that contribute to the efficacy of the regional MPA network is key (WCPA/IUCN 2007). As such, promoting and supporting national and subregional MPA networks in the Caribbean is crucial. At least a dozen countries in the Caribbean have designed or are designing national MPA networks, and there are a number of organizations strengthening or establishing MPAs, conducting MPA research, and building capacity at the national and subregional level (Wells et al. 2008). There are already some positive examples of smaller-scale MPA networks in the Caribbean that are contributing to the overall ecological coherence of the region. As noted above, Belize’s MPA network is one such example, and the Mesoamerican Reef Programme is also working towards creating a resilient MPA network in Mexico, Belize, Guatemala, and Honduras. The Caribbean Challenge Initiative, the Caribbean-specific target to protect 20% of the nearshore marine environments of participating countries and territories by 2020, is also contributing to overall ecological coherence by encouraging national-level MPA networks. So far, eleven Caribbean countries and territories committed to the target and five of them met or exceeded the goal (Caribbean Challenge Initiative 2020; The Nature Conservancy 2021). The drawback to national goals like the Caribbean Challenge Initiative is that they do not promote international cooperation and transboundary protection, which is especially important in the marine environment due to the transboundary properties of many ecosystems and species that move across national jurisdictions.

5.3 Comparison to Other Ecological Coherence Assessments

It is not surprising that ecological coherence was very unlikely to be reached in the Wider Caribbean Region considering that ecological coherence has not been reached in any existing MPA network (Rees et al. 2018). When compared to the other three ecological coherence assessments that applied the same aggregation methodology used in this assessment, the Wider Caribbean Region is most similar to the 2016 HELCOM assessment (Table 9). Three of the four main criteria in the Wider Caribbean Region and HELCOM had the same likelihood of ecological coherence (Table 9). In both reports, representativity had the highest likelihood of ecological coherence and adequacy had the lowest likelihood, with the final outcome for both regions being that ecological coherence is very unlikely. Ecological coherence was not reached in any of the four assessments.

Table 9. A comparison of the results of the integration tables and the likelihood of ecological coherence from four ecological coherence assessments.

	Wider Caribbean Region			HELCOM (Baltic Sea) (HELCOM 2016)			Central Baltic Sea (basic assessment) (Wolters et al. 2015)			Central Baltic Sea (detailed assessment) (Wolters et al. 2015)		
	Score	Likelihood	Overall	Score	Likelihood	Overall	Score	Likelihood	Overall	Score	Likelihood	Overall
Represent.	1.13	Likely	Ecological coherence is very unlikely	1.1	Likely	Ecological coherence is very unlikely	0.8	Unlikely	Ecological coherence is unlikely	1.5	Likely	Ecological coherence is unlikely
Replication	0.94	Unlikely		1.2	Likely		2.2	Very likely		2.2	Very likely	
Connect.	0.68	Unlikely		0.6	Unlikely		0.8	Unlikely		0.7	Unlikely	
Adequacy	0.48	Very unlikely		0.3	Very unlikely		0.7	Unlikely		0.6	Unlikely	

These results suggest that the Wider Caribbean Region is not unique in its insufficient marine protection, particularly in terms of adequacy. When comparing the percent of MPAs classified as high-protection IUCN categories (Ia, Ib, and II), the Wider Caribbean Region, the entire Baltic Sea region (HELCOM 2016), and the Central Baltic Sea (Wolters et al. 2015) all have similarly low percentage protection - all below the 30% target (Figure 31). Because no-take marine reserves are the most effective protected areas in the ocean (Sala and Giakoumi 2017), more no-take MPAs should be established.

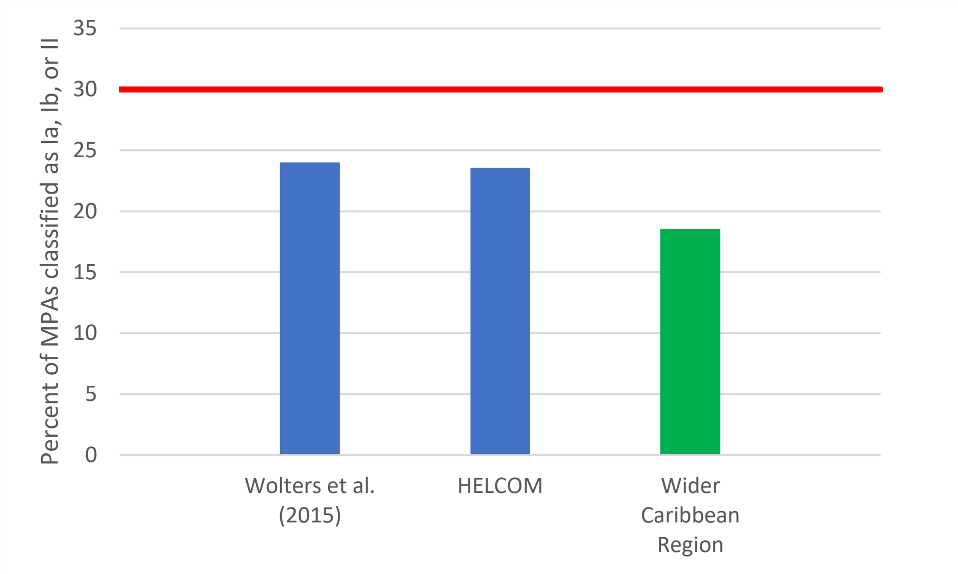

Figure 31. A comparison of the percentage of MPAs classified as IUCN protection categories Ia, Ib or II in three regions. Wolters et al.. (2015) is the Central Baltic Sea and HELCOM is the entire Baltic Sea.

The results were similar when comparing the sizes of MPAs in MPA networks in the Caribbean and Europe. Figure 32 shows the percent of MPAs in various MPA networks that are greater than 5 km^2. None of the regions or subregions met the target used in this assessment of 75% of sites greater than 5 km^2 (Figure 32). In fact, the Wider Caribbean Region had the largest percentage of MPAs greater than 5 km^2 (63%). This indicates a more global problem of an overall MPA distribution skewed towards smaller MPAs.

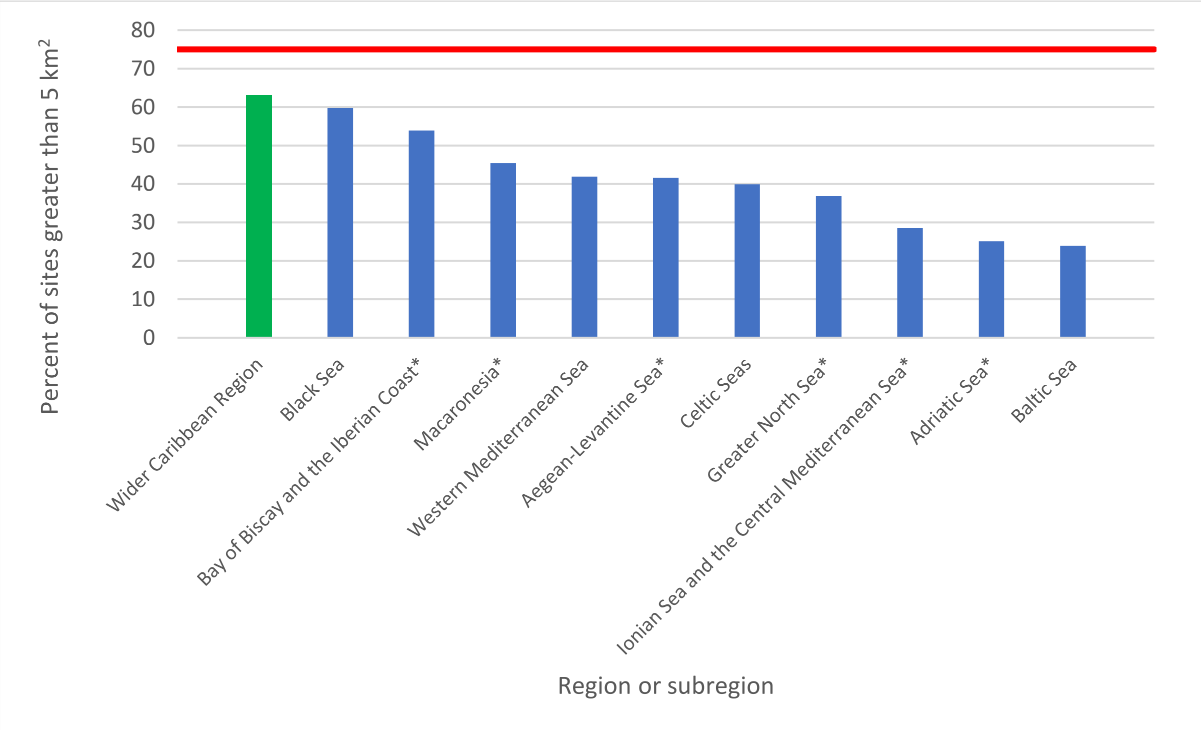

Figure 32. A comparison of MPA sizes in regional and subregional MPA networks. Data for other locations is from Agnesi et al. (2017). * Indicates subregion.

When compared to European MPA networks, the Wider Caribbean Region is about average in terms of percent MPA coverage. Of the twelve MPA networks compared in Figure 33, only three passed the 10% coverage target. With 7.74% of the oceans covered by MPAs globally, the target was not met on a global scale either (UNEP-WCMC & IUCN 2021b). This target is based on Aichi Target 11: 10% of coastal and marine areas should be protected by 2020. This global target expired in 2020 and the post-2020 target is 30% of coastal and marine areas protected by 2030, as per the zero draft of the upcoming Global Biodiversity Framework (CBD 2020), which will be a challenge based on the current conditions.

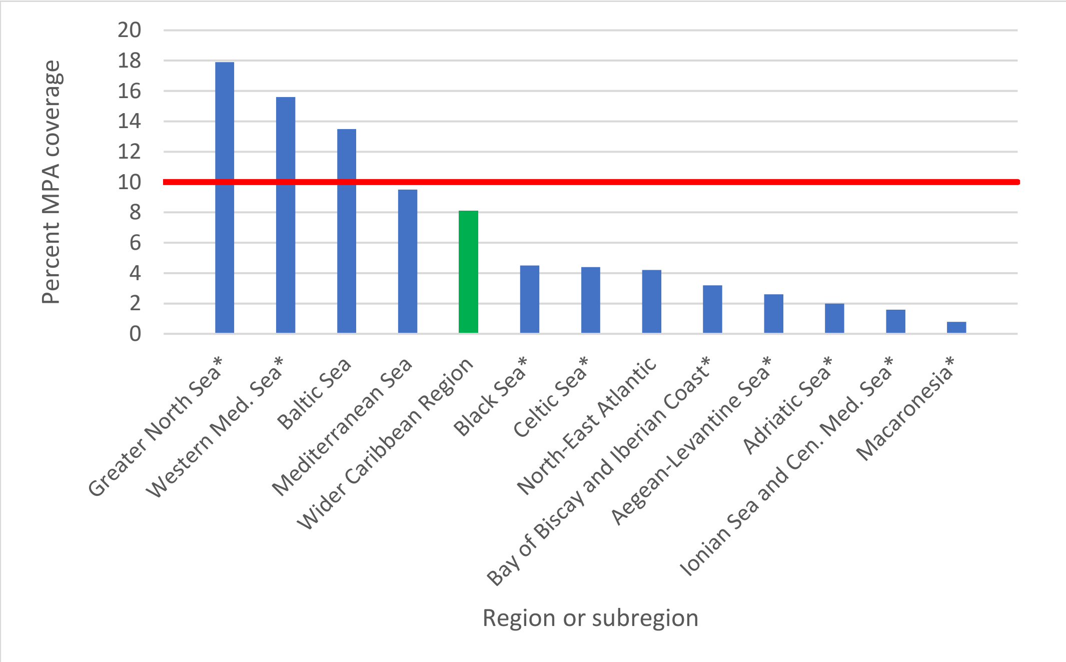

Figure 33**.** A comparison of percent MPA coverage in regional and subregional MPA networks. Data for other locations is from EEA (2015). * Indicates subregion.

5.4 Data Gaps, Limitations, and Proposals for Improvement

5.4.1 Data Gaps and Limitations

All previous ecological coherence assessments have been undertaken in Europe, a data-rich region compared to the Caribbean. The lack of Caribbean-specific and Caribbean-wide data were significant limitations in this assessment. This was specifically true for species data. Some ecological coherence assessments (HELCOM 2016; Wolters et al. 2015) used data on the presence and absence of indicator species and/or threatened species in the region in tests for representativity and connectivity, which can paint a more detailed picture of the ecosystem than data on habitats and biogeographic zones alone. Unfortunately, this type of region-wide species distribution data is not available in the Caribbean.

The reliance on modelled substrate/depth habitat data for this assessment was another data limitation. All eight of the substrate/depth habitat data used in this assessment is modelled data, based on the extrapolation of core samples. Using modelled data always increases uncertainty in final outputs (Heuvelink 1998). An estimation for this uncertainty was quantified and applied to the aggregation of the habitat-related representativity, replication, and connectivity tests (Appendix B) and contributed to lower overall scores for those tests. Having more empirical substrate/depth habitat data would decrease the uncertainty of these tests in future assessments.

An important piece of information that was not included in this assessment was information on the features protected by the MPAs. Ecological coherence assessments generally assume that if an MPA contains the feature of interest, it contributes towards passing that test. This assumption may grossly overestimate the ecological coherence of the network. For example, if a coral reef patch is found in two MPAs, it automatically counts as two replicates. However, if the coral reef patch is not protected and potentially very damaged in one or both MPAs, it is ecologically not contributing as a replicated feature and should not be counted as such. MPAs are established with a wide range of conservation goals and protection levels, and this should be considered more in ecological coherence assessments. Tests using no-take MPAs take this into account to some degree, but more data could improve this greatly. Ideally, a database could be created that includes the protected features of each MPA so that only the features that are legally protected in each MPA would be included in the assessment. Additionally, more complete information on protection level of MPAs is needed. For instance, there are no-take MPAs within the study area in Mexico that are not included in the WDPA database, which likely skewed the no-take tests (Jessen et al. 2017). Ideally, a spatial component to the protection level should be included in such a database as well, because many MPAs have zones with different levels of protection, but as the data is now it is impossible to know which where the different zones are located.

5.4.2 A Reflection on Target Setting

A number of scientific knowledge gaps still exist that impede the confidence in setting targets for ecological coherence. This is particularly important because due to the nature of the methodology, the chosen target for each test can wholly determine the outcome of ecological coherence. Great consideration was taken into account when setting the targets for each test, with scientific literature and previous ecological coherence assessments consulted to develop every target. However, some targets are more strongly supported by science than others and there is contradicting information in the literature. This was particularly true for the connectivity tests and the human impact test. Because this is the first ecological coherence assessment conducted in the Caribbean, it was difficult to determine targets specific to this region and in many cases the targets used in European seas were applied to this assessment. It would be particularly useful to have habitat-specific protection targets, as different habitats require different levels of protection. Specific habitat targets exist in Europe and Australia, but not in the Caribbean. Improved scientific data for targets, especially in the Caribbean would be a huge asset to future ecological coherence assessments.

Target setting is also dependent on the scale of the analysis, and this should be considered when planning ecological coherence assessments. This is particularly true for the replication tests, where whether the threshold is met is highly dependent on the scale of the analysis, being much easier to reach the threshold if the area analyzed is larger. The replication threshold in this analysis was set near the average of the thresholds set by other ecological coherence assessments, but the target may have been set too low, considering the large size of the study area compared to some other ecological coherence assessments.

5.4.3 Scrutinizing the Methodology

The methodology used in this assessment was modelled after those used in other ecological coherence assessments, but there were still some associated limitations and suggestions for improvement. In particular, the approach to evaluate connectivity was extremely simplified and could only provide a first glance at connectivity. Connectivity is a complex concept, but this approach was only based on two dispersal distances (20 km and 80 km). The 20 km threshold is based on the recommendation for distance between MPAs in tropical areas (Fernandes et al. 2009; Fernandes et al. 2012) and is designed to capture the larval dispersal and adult movement patterns of many species (Fernandes et al. 2012), but it is a grossly simplified measure of MPA connectivity. Ideally, a more appropriate analysis would include species specific dispersals, currents, and information on stepping stone habitats. However, such analyses are extremely complex, difficult to do on such a large scale, and require species-specific empirical data and high-resolution environmental data (Cowen et al. 2007).

Additionally, this methodology may have greatly overestimated connectivity of MPAs for two reasons. First, the connectivity methodology does not take land into account. An MPA only needs to be within a 20/80 kilometers as-the-crow-flies of a single other MPA to be considered connected. This does not consider that the other MPA may be on the other side on an island, or may not actually be connected due to currents or other barriers. Second, the test of habitat connectivity only measures the distance between MPAs containing identical habitat patches, rather than the distance between the habitat patches themselves, which would result in MPAs deemed connected even if the habitat patches themselves are more than 80 km apart.

The connectivity methodology could also be improved by testing specifically for connectivity for migratory species. Many MPAs and MPA networks are not planned for migratory species even though migratory species depend on the region. The Migratory Connectivity in the Ocean (MiCO) data could be used in the future to assess connectivity for migratory species in MPA networks, but the publicly available MiCO data is currently not complete enough.

5.4.4 The Role of Management in an MPA Assessment

Although ecological coherence is a major step towards an effective MPA network, it is only half of the story. Management effectiveness of MPAs should not be overlooked. Aichi Target 11 calls for “effectively and equitably managed, ecologically representative and well-connected systems of protected areas” (CBD 2010). MPA management effectiveness must be evaluated together with ecological coherence to see the whole picture of the MPA network. Unfortunately, management is often limited by funding, training, and expertise (Silva and Desilvestre 1986). This is especially true in the Caribbean, where only 16% of no-take MPAs in the region meet the highest level of management compliance (Appeldoorn and Lindeman 2003).

The first step to improving management effectiveness is to thoroughly and frequently assess management effectiveness, which is currently not occurring in the Caribbean. To assess management effectiveness, Protected Area Management Effectiveness (PAME) evaluations are conducted in protected areas. PAME evaluations are defined as "the assessment of how well protected areas are being managed – primarily the extent to which management is protecting values and achieving goals and objectives" (Hockings et al. 2006). Of the 900 MPAs in the Caribbean included in this research, only 119 (13%) have completed PAME evaluations, according to the most comprehensive global database of management effectiveness assessments for protected areas, the Global Database on Protected Area Management Effectiveness (GD-PAME) (UNEP-WCMC and IUCN 2021a; see Appendix G). While this number does not give any indication of MPA management effectiveness, it highlights that only a small percentage of MPAs in the Caribbean have even been assessed. Following the philosophy that the process of evaluation itself can bring about improvements, more PAME evaluations should be conducted in the Caribbean to improve management effectiveness.

As well as increasing the number of PAME evaluations conducted at the individual MPA level in the Caribbean, a region wide MPA management effectiveness plan could be implemented to better understand and improve the overall state of MPA management in the region. A number of location-specific methods have already been developed for assessing MPA management effectiveness at the subregional and regional level. For example, methods have been developed in Micronesia (Isechal et al. 2012), the Mediterranean (Tempesta and Otero 2013; MedPAN & SPA/RAC 2019), the Coral Triangle (National Coral Triangle Initiative Coordinating Committee 2011), and OSPAR (OSPAR 2019). In OSPAR, management effectiveness of the MPAs in the network is assessed periodically using a simple questionnaire-based approach (OSPAR 2019). CEP could take the lead in developing and implementing a regional MPA management effectiveness assessment in the Caribbean like that of OSPAR.

Chapter 6: Conclusions

6.1 Conclusions Regarding Ecological Coherence in the Wider Caribbean Region

This assessment successfully provides a much-needed holistic overview of the Wider Caribbean Region MPA network. It represents the first ecological coherence assessment of the Caribbean MPA network, and the first ecological coherence assessment outside of Europe. Ecological coherence was assessed using four main criteria and the results were aggregated for a final likelihood of ecological coherence. In terms of **representativity**, ecological coherence was likely to have been achieved. However, the region did not meet the quantitative aspect of Aichi Target 11 of 10% MPA coverage. To reach this target, more than 530,000 additional km^2 would need to be protected. Ecological coherence in terms of **replicability** was unlikely to have been achieved. Most replication targets were achieved when all MPAs were included, but far fewer targets were met when only no-take MPAs were analyzed. Ecological coherence was also unlikely to have been achieved in terms of **connectivity**. The MPAs and no-take MPAs were connected based on a proxy species dispersal distance, but not all the habits were connected, particularly the deep habitats. **Adequacy** had the lowest ecological coherence score and was very unlikely to have achieved ecological coherence. Adequacy was especially lacking in terms of minimum size of MPAs and the amount of MPAs that are no-take. To get closer to ecological coherence, the region should focus on increasing the percentage of MPAs that are entirely no-take or have no-take zones, as well as increasing the number of large MPAs. The criterion with the lowest score determines the overall likelihood of ecological coherence of the network, thus the entire MPA network was determined to be very unlikely to have reached ecological coherence. This final outcome was not surprising, considering that not a single MPA network has been deemed ecologically coherent to date.

This assessment revealed some distributional gaps in the network. Within the region – just considering the tests that were assessed at the subregional or biogeographic zone level – the Western Caribbean and Southwestern Caribbean were the best examples of marine protection. The Gulf of Mexico, Florida and Guianan areas passed the fewest tests and thus showed the largest gaps in marine protection.

The overall methodology used in this assessment was not new, but this was the first application of this methodology outside of Europe and some of the individual tests were novel. For example, the human impact test has not been used in other tests, and the test for ecologically important areas incorporated datasets that had not been used in any other ecological coherence assessment. Both tests worked well and provided valuable results. I recommend their use in future assessments, although the targets for both tests should be continued to be scrutinized. The methodology for aggregating the criteria was successful and is recommended to be used in future ecological coherence assessments. The wide range of uncertainties in the data, methods and targets influenced the final results during the aggregation phase, and were an indication that the assessments, while valuable, are not fully developed and should continue to be improved upon with new research.

6.2 Recommendations for Future Research

This assessment demonstrated that this methodology can be applied outside of Europe. Other MPA networks around the world can apply this methodology to retroactively assess ecological coherence both in MPA networks established on an *ad hoc* basis, or in deliberately established MPA networks. This methodology can also be applied to MPA networks at different scales. For example, this methodology should be used to assess ecological coherence of smaller scale MPA networks within the Caribbean, such as at the subregional or national level. More locally specific information gleaned from smaller scale ecological coherence assessments could aid local and national governments and MPA managers.

Future assessments in the Caribbean could incorporate regionally specific tests. For example, a test that incorporates the importance of connectivity of coral reef, seagrass and mangrove habitats could be included because connectivity of these three habitats is especially important for many species' life stages, resilience, and nutrient transfer. Additionally, testing for connectivity for migratory species should be explored as more data becomes available, particularly from MiCO.

Filling major data gaps could allow for the incorporation of more robust tests in future assessments and would overall help the effort to reach ecological coherence. For example, more data on specific species and habitat distributions and agreed upon categorizations for threatened/declining habitats (similar to the Habitats Directive Annex of species and habitats in Europe) would allow for habitat-specific targets, which would provide more robust results. Such data would also contribute to reducing uncertainties in the assessment. Additionally, the use of systematic conservation tools, such as Marxan, would be extremely beneficial for expanding the MPA network and identifying where to allocate limited resources available for marine conservation, but it would require more spatial information on species and habitats. There is a huge potential to use a systematic conservation tool to identify sites to help the region reach ecological coherence, and this assessment may provide the groundwork for such an endeavor.

In general, research that reduces the uncertainties in the data, methods, and targets should be promoted. Some of the tests lacked scientifically-sound targets, and specifically researching factors that would increase confidence in the targets would increase the vigor of the tests. To help reduce uncertainty in the methods, specifically for the connectivity tests, research should focus on better understanding species' life cycles, such as dispersal behaviors and distances. Overall, uncertainty in the methods would be significantly decreased if there were more information on the specific features that are protected by individual MPAs. Developing a comprehensive database containing this information is highly recommended.

6.3 Recommendations for Managers, Governments, and Other Stakeholders

This assessment provides an overview of the status of the MPA network in the Caribbean and will hopefully inspire local MPA managers and governments to take action to make the network more ecologically coherent. This assessment emphasizes the interconnectedness of MPAs and will hopefully foster inspiration to focus on MPA networks, rather than individual MPAs in the Caribbean.

Considering that the Wider Caribbean Region MPA network is very unlikely to have reached ecological coherence, significant political will is needed to bring the network to ecological coherence, but specific actions can help pave the road to ecological coherence. As adequacy was the determining factor in the overall very low score of ecological coherence in the network, organizations, individuals, and governments responsible for MPA planning should prioritize increasing the adequacy of the network. Specifically, the establishment of larger MPAs and no-take MPAs (or MPAs with no-take zones) should be prioritized.

Already existing governing structures in the region can be strengthened to increase environmental protection and ecological coherence of the network. The SPAW Protocol of CEP can focus its efforts on encouraging MPAs to be established such that they increase the ecological coherence of the network. Additionally, CEP can increase funding and resources to CaMPAM to increase its efficacy as a social network that builds capacity and brings together MPA practitioners. CEP can also develop and implement a regional MPA management effectiveness assessment in the Caribbean similar to that of OSPAR, because management effectiveness is a crucial aspect of a successful MPA network.

Working to increase ecological coherence at smaller scales within the region will also contribute to ecological coherence in the region as a whole. Therefore, stakeholders should consider applying this methodology to national and subregional MPA networks within the region. This assessment highlighted gaps at the regional and subregional level, but it was not feasible to assess ecological coherence at the national scale due to the politically complex nature of the Caribbean. This region-wide assessment can provide a framework and serve as a broad long-term goal, but smaller scale assessments can drive specific actions. At a smaller scale, local practitioners and governments can innovate and adapt their MPA networks for the ecology and culture of the area to fill the gaps. Countries and subregions within the Caribbean should consider making more official MPA networks and more social networks of MPA managers that will facilitate more sharing of ideas and experiences between practitioners.

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Appendices

Appendix A. A comparison of tests used in ecological coherence assessments.

Appendix B. Uncertainty values and their justification.

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Appendix G. A list of MPAs considered in the assessment.

Appendix A. A comparison of tests used in ecological coherence assessments

	Number of times used	OSPAR (2017)	OSPAR (2013)	OSPAR (2008)	HELCOM (2016)	MedPAN & SPA/RAC (2019)	European Commission (Wolters et al. 2015)	Celtic Sea (Foster et al. 2017)	California (Saarman et al. 2013)	Agnesi et al. 2017
Representativity										
General coverage	4				x		x	x		x
Biogeographic representation/ecoregions (Dinter, etc.)	6	x	x	x		x	x	x		
Benthic marine landscapes/habitats/EUNIS habitats	8	x	x		x	x	x	x	x	x
Depth classes	5		x			x	x	x		x
Certain species	1 (4)		Not cmplt	Not cmplt	Not cmplt	Not cmplt	x			
Ecologically and biologically significant areas	1					x				
Replication										
Benthic marine landscapes/EUNIS habitats	6	x	x		x			x	x	x
Replication of biogeographic zones/broad landscape	3				x	x	x			
Connectivity										
Number of connections between MPAs (distance)	1				x					
Number of connections (habitat patches)	1				x					
Distance between MPAs	5	x	x	x		x	x			
Distance between MPA - same habitat	4		x					x	x	x
Adequacy										
Size of MPAs	7		x		x	x	x	x	x	x
Proportion of habits protected	2		x					x		
Level of protection	2 (1)				x	Not cmplt	x			
Size distribution of habitat patches	1							x		
Threats to biodiversity	1 (1)				x	Not cmplt				

Appendix B. Uncertainty values and their justification

Main criterion	Subcriterion	Uncertainty value of data	Justification	Uncertainty value of target	Justification	Uncertainty value of method	Justification
Representativity	General coverage	Low (1)	The data is shapefiles of MPAs provided by countries	Low (1)	The target is based on recommendations from the CBD and used in other literature	Low (1)	This is a standard GIS analysis
	Biogeographic zones	Low (1)	The biogeographic zones are broad scale, generally agreed upon marine zones	Low (1)	The target is based on recommendations from the CBD and used in other literature	Low (1)	This is a standard GIS analysis
	Ecologically important areas	Low (1)	The ecologically important areas have been identified by high-profile organizations	Moderate (.75)	This target was used in MedPAN & SPA/RAC (2019), but only for preliminary analysis	Low (1)	This is a standard GIS analysis
	Habitats	Moderate (.75)	Data from 8 of the 13 habitat types was interpolated from point data. Interpolated data always includes some uncertainty	Moderate (.75)	Many other assessments use different targets depending on the rarity/importance of each habitat type. That information is not available for the Caribbean, however.	Low (1)	This is a standard GIS analysis
Replicability	Biogeographic zones	Low (1)	The biogeographic zones are broad scale, generally agreed upon marine zones	Moderate (.75)	The theoretical threshold of 3 replications was chosen because it is the approximate average of thresholds used in replication tests in other assessments, but it is rather low, especially for a region-wide analysis.	High (.5)	The method is very scale specific and would change drastically if done on a sub-regional scale instead.

	No-take biogeographic zones	Moderate (.75)	The biogeographic zones are broad scale, generally agreed upon marine zones. The WDPA information regarding no-take zones is incomplete and not precise. Some no-take MPAs are not included in the dataset and the specific location of no-take zones within individual MPAs with multiple levels of protection is not known.	Moderate (.75)	The theoretical threshold of 3 replications was chosen because it is the approximate average of thresholds used in replication tests in other assessments, but it is rather low, especially for a region-wide analysis.	High (.5)	The method is very scale specific and would change drastically if done on a sub-regional scale instead.
	Habitats	Moderate (.75)	Data from 8 of the 13 habitat types was interpolated from point data. Interpolated data always includes some uncertainty	Moderate (.75)	The theoretical threshold of 3 replications was chosen because it is the approximate average of thresholds used in replication tests in other assessments, but it is rather low, especially for a region-wide analysis. Habitat-specific targets would be better.	High (.5)	The method is very scale specific and would change drastically if done on a sub-regional scale instead. The method does not consider whether the specific habitat patches are actually protected by the MPAs

	No-take habitats	High (.5)	Data from 8 of the 13 habitat types was interpolated from point data. Interpolated data always includes some uncertainty The WDPA information regarding no-take zones is incomplete and not precise. Some no-take MPAs are not included in the dataset and the specific location of no-take zones within individual MPAs with multiple levels of protection is not known.	Moderate (.75)	The theoretical threshold of 3 replications was chosen because it is the approximate average of thresholds used in replication tests in other assessments, but it is rather low, especially for a region-wide analysis. Habitat-specific targets would be better.	High (.5)	The method is very scale specific and would change drastically if done on a sub-regional scale instead. The method does not consider whether the specific habitat patches are actually protected by the MPAs
Connectivity	Distance between MPAs	Low (1)	The data is shapefiles of MPAs provided by countries	Moderate (.75)	The 20 km threshold was specifically suggested by Fernandes et al. (2013) as the maximum distance between MPAs in tropical areas. The 75% threshold was used by Agnesi et al. (2017) for similar tests but was not scientifically justified.	High (.5)	The method did not take land into account. For instance, MPAs on opposite sides of a small island may be "connected" in the test but in reality are not connected. This method overemphasizes a single connection between two MPAs and does not account for the greater benefits of highly connected MPAs

	Distance between no-take MPAs	Moderate (.75)	The WDPA information regarding no-take zones is incomplete and not precise. Some no-take MPAs are not included in the dataset and the specific location of no-take zones within individual MPAs with multiple levels of protection is not known.	Moderate (.75)	The 20 km threshold was specifically suggested by Fernandes et al. (2012) as the maximum distance between no-take MPAs. The 75% threshold was used by Agnesi et al. (2017) for similar tests but was not scientifically justified.	High (.5)	The method did not take land into account. For instance, MPAs on opposite sides of a small island may be "connected" in the test but in reality are not connected. This method overemphasizes a single connection between two MPAs and does not account for the greater benefits of highly connected MPAs
	Distance between habitats	Moderate (.75)	Data from 8 of the 13 habitat types was interpolated from point data. Interpolated data always includes some uncertainty	Moderate (.75)	The 80km threshold was used by Foster et al. (2017) for the same test. The 75% threshold was used by Agnesi et al. (2017) for similar tests but was not scientifically justified.	High (.5)	The method did not take land into account. For instance, habitat patches on opposite sides of a small island may be "connected" in the test but in reality are not connected. This method overemphasizes a single connection between two habitat patches and does not account for the greater benefits of highly connected habitat patches. This method assumes that marine organisms can cross any other habitat or environment to reach another patch of similar habitat. This method also measured the distance between MPAs containing identical habitat

							patches, rather than the distance between habitat patches, which can positively skew the results.
Adequacy	Size of MPAs	Low (1)	The data is shapefiles of MPAs provided by countries	Moderate (.75)	The size and percent thresholds came from Agnesi et al. (2017), but the 75% threshold was not scientifically justified.	High (.5)	The data may be skewed by the preparation process, which may have clipped some MPAs to either smaller or larger than their actual size because of misalignment of the coast shapefile and the MPA shapefiles
	Level of protection	Moderate (.75)	The WDPA information regarding no-take zones is incomplete and not precise. Some no-take MPAs are not included in the dataset.	Low (1)	The 10%-30% threshold was used by HELCOM (2016) and suggested by the Fifth Parks Congress.	Low (1)	This is a basic percentage calculation
	Human Impact	Moderate (.75)	The Halpern et al. (2019) data is including some modelled layers. Modelled data includes some uncertainties.	High (.5)	The threshold was arbitrary as no test has been done like this in other assessments.	High (.5)	The cutoff point between what constitutes high and low impact areas was relatively arbitrary and may have skewed the results

Appendix C. The aggregation table of the representativity tests

	Subcriteria result	Subcriteria target	Subcriteria ratio (result/target)	Adjusted subcriteria ratio (result/target) (capped at 2)	Uncertainty in data	Uncertainty in target	Uncertainty in method	Average uncertainty	Weighted average of subcriteria (subcriteria ratio x mean uncertainty
Representativity of MPAs in subregions:									
Bahamian	6.66	10.00	0.67	0.67	1.00	1.00	1.00	1.00	0.67
Eastern Caribbean	19.06	10.00	1.91	1.91	1.00	1.00	1.00	1.00	1.91
Florida	7.06	10.00	0.71	0.71	1.00	1.00	1.00	1.00	0.71
Greater Antilles	5.41	10.00	0.54	0.54	1.00	1.00	1.00	1.00	0.54
Guianan	1.18	10.00	0.12	0.12	1.00	1.00	1.00	1.00	0.12
Gulf of Mexico	1.44	10.00	0.14	0.14	1.00	1.00	1.00	1.00	0.14
Southern Caribbean	6.24	10.00	0.62	0.62	1.00	1.00	1.00	1.00	0.62
Southwestern Caribbean	11.97	10.00	1.20	1.20	1.00	1.00	1.00	1.00	1.20
Western Caribbean	25.89	10.00	2.59	2.00	1.00	1.00	1.00	1.00	2.00
Representativity of MPAs in biogeographic zones:									
Amazonia	2.08	10.00	0.21	0.21	1.00	1.00	1.00	1.00	0.21
Bahamian	13.19	10.00	1.32	1.32	1.00	1.00	1.00	1.00	1.32
Carolinian	1.04	10.00	0.10	0.10	1.00	1.00	1.00	1.00	0.10
Eastern Caribbean	35.22	10.00	3.52	2.00	1.00	1.00	1.00	1.00	2.00
Equatorial Atlantic	15.63	10.00	1.56	1.56	1.00	1.00	1.00	1.00	1.56
Floridian	11.84	10.00	1.18	1.18	1.00	1.00	1.00	1.00	1.18
Greater Antilles	24.64	10.00	2.46	2.00	1.00	1.00	1.00	1.00	2.00
Guianan	2.65	10.00	0.27	0.27	1.00	1.00	1.00	1.00	0.27
Gulf Stream	3.53	10.00	0.35	0.35	1.00	1.00	1.00	1.00	0.35
Inter American Seas	5.81	10.00	0.58	0.58	1.00	1.00	1.00	1.00	0.58

North Atlantic Transitional	0.00	10.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00
North Central Atlantic Gyre	5.58	10.00	0.56	0.56	1.00	1.00	1.00	1.00	0.56
Northern Gulf of Mexico	3.21	10.00	0.32	0.32	1.00	1.00	1.00	1.00	0.32
Southern Caribbean	15.84	10.00	1.58	1.58	1.00	1.00	1.00	1.00	1.58
Southern Gulf of Mexico	6.85	10.00	0.69	0.69	1.00	1.00	1.00	1.00	0.69
Southwestern Caribbean	16.42	10.00	1.64	1.64	1.00	1.00	1.00	1.00	1.64
Western Caribbean	58.43	10.00	5.84	2.00	1.00	1.00	1.00	1.00	2.00
Representativity of Ecologically Important Areas									
Bahamian	41.32	10.00	4.13	2.00	1.00	0.75	1.00	0.92	1.83
Eastern Caribbean	19.89	10.00	1.99	1.99	1.00	0.75	1.00	0.92	1.82
Florida	96.80	10.00	9.68	2.00	1.00	0.75	1.00	0.92	1.83
Greater Antilles	32.74	10.00	3.27	2.00	1.00	0.75	1.00	0.92	1.83
Guianan	1.12	10.00	0.11	0.11	1.00	0.75	1.00	0.92	0.10
Gulf of Mexico	31.47	10.00	3.15	2.00	1.00	0.75	1.00	0.92	1.83
Southern Caribbean	11.57	10.00	1.16	1.16	1.00	0.75	1.00	0.92	1.06
Southwestern Caribbean	62.28	10.00	6.23	2.00	1.00	0.75	1.00	0.92	1.83
Western Caribbean	31.35	10.00	3.13	2.00	1.00	0.75	1.00	0.92	1.83
Representativity of Habitats									
Coral Reef	48.99	10.00	4.90	2.00	0.75	0.75	1.00	0.83	1.67
Mangroves	72.85	10.00	7.29	2.00	0.75	0.75	1.00	0.83	1.67
Saltmarsh	34.57	10.00	3.46	2.00	0.75	0.75	1.00	0.83	1.67
Seagrass	45.44	10.00	4.54	2.00	0.75	0.75	1.00	0.83	1.67
Seamounts	15.44	10.00	1.54	1.54	0.75	0.75	1.00	0.83	1.29
Shallow Hard	30.35	10.00	3.04	2.00	0.75	0.75	1.00	0.83	1.67
Shallow Soft	10.29	10.00	1.03	1.03	0.75	0.75	1.00	0.83	0.86
Shelf Hard	20.53	10.00	2.05	2.00	0.75	0.75	1.00	0.83	1.67
Shelf Soft	4.24	10.00	0.42	0.42	0.75	0.75	1.00	0.83	0.35

Slope Hard	38.03	10.00	3.80	2.00	0.75	0.75	1.00	0.83	1.67
Slope Soft	6.23	10.00	0.62	0.62	0.75	0.75	1.00	0.83	0.52
Deep Hard	11.49	10.00	1.15	1.15	0.75	0.75	1.00	0.83	0.96
Deep Soft	5.40	10.00	0.54	0.54	0.75	0.75	1.00	0.83	0.45

AVERAGE	**1.13**
	Likely

Appendix D. The aggregation table of the replicability tests

	Subcriteria result	Subcriteria target	Subcriteria ratio (result/target)	Adjusted subcriteria ratio (result/target) (capped at 2)	Uncertainty in data	Uncertainty in target	Uncertainty in method	Average uncertainty	Weighted average of subcriteria (subcriteria ratio x mean uncertainty
Replicates of biogeographic zones									
Amazonia	1.00	3.00	0.33	0.33	1.00	0.75	0.50	0.75	0.25
Bahamian	66.00	3.00	22.00	2.00	1.00	0.75	0.50	0.75	1.50
Carolinian	6.00	3.00	2.00	2.00	1.00	0.75	0.50	0.75	1.50
Eastern Caribbean	91.00	3.00	30.33	2.00	1.00	0.75	0.50	0.75	1.50
Equatorial Atlantic	0.00	3.00	0.00	0.00	1.00	0.75	0.50	0.75	0.00
Floridian	42.00	3.00	14.00	2.00	1.00	0.75	0.50	0.75	1.50
Greater Antilles	162.00	3.00	54.00	2.00	1.00	0.75	0.50	0.75	1.50
Guianan	68.00	3.00	22.67	2.00	1.00	0.75	0.50	0.75	1.50
Gulf Stream	0.00	3.00	0.00	0.00	1.00	0.75	0.50	0.75	0.00
Inter American Seas	41.00	3.00	13.67	2.00	1.00	0.75	0.50	0.75	1.50
North Atlantic Transitional	0.00	3.00	0.00	0.00	1.00	0.75	0.50	0.75	0.00
North Central Atlantic Gyre	7.00	3.00	2.33	2.00	1.00	0.75	0.50	0.75	1.50
Northern Gulf of Mexico	114.00	3.00	38.00	2.00	1.00	0.75	0.50	0.75	1.50
Southern Caribbean	47.00	3.00	15.67	2.00	1.00	0.75	0.50	0.75	1.50
Southern Gulf of Mexico	20.00	3.00	6.67	2.00	1.00	0.75	0.50	0.75	1.50
Southwestern Caribbean	78.00	3.00	26.00	2.00	1.00	0.75	0.50	0.75	1.50
Western Caribbean	32.00	3.00	10.67	2.00	1.00	0.75	0.50	0.75	1.50

Replicates of no-take MPAs in biogeographic zones									
Amazonia	0.00	3.00	0.00	0.00	0.75	0.75	0.50	0.67	0.00
Bahamian	4.00	3.00	1.33	1.33	0.75	0.75	0.50	0.67	0.89
Carolinian	0.00	3.00	0.00	0.00	0.75	0.75	0.50	0.67	0.00
Eastern Caribbean	29.00	3.00	9.67	2.00	0.75	0.75	0.50	0.67	1.33
Equatorial Atlantic	0.00	3.00	0.00	0.00	0.75	0.75	0.50	0.67	0.00
Floridian	9.00	3.00	3.00	2.00	0.75	0.75	0.50	0.67	1.33
Greater Antilles	10.00	3.00	3.33	2.00	0.75	0.75	0.50	0.67	1.33
Guianan	0.00	3.00	0.00	0.00	0.75	0.75	0.50	0.67	0.00
Gulf Stream	0.00	3.00	0.00	0.00	0.75	0.75	0.50	0.67	0.00
Inter American Seas	4.00	3.00	1.33	1.33	0.75	0.75	0.50	0.67	0.89
North Atlantic Transitional	0.00	3.00	0.00	0.00	0.75	0.75	0.50	0.67	0.00
North Central Atlantic Gyre	1.00	3.00	0.33	0.33	0.75	0.75	0.50	0.67	0.22
Northern Gulf of Mexico	0.00	3.00	0.00	0.00	0.75	0.75	0.50	0.67	0.00
Southern Caribbean	0.00	3.00	0.00	0.00	0.75	0.75	0.50	0.67	0.00
Southern Gulf of Mexico	0.00	3.00	0.00	0.00	0.75	0.75	0.50	0.67	0.00
Southwestern Caribbean	5.00	3.00	1.67	1.67	0.75	0.75	0.50	0.67	1.11
Western Caribbean	11.00	3.00	3.67	2.00	0.75	0.75	0.50	0.67	1.33
Replicates of habitats									
Coral Reef	236.00	3.00	78.67	2.00	0.75	0.75	0.50	0.67	1.33
Mangroves	258.00	3.00	86.00	2.00	0.75	0.75	0.50	0.67	1.33
Saltmarsh	222.00	3.00	74.00	2.00	0.75	0.75	0.50	0.67	1.33
Seagrass	222.00	3.00	74.00	2.00	0.75	0.75	0.50	0.67	1.33
Seamounts	31.00	3.00	10.33	2.00	0.75	0.75	0.50	0.67	1.33

Shallow Hard	171.00	3.00	57.00	2.00	0.75	0.75	0.50	0.67	1.33
Shallow Soft	474.00	3.00	158.00	2.00	0.75	0.75	0.50	0.67	1.33
Shelf Hard	69.00	3.00	23.00	2.00	0.75	0.75	0.50	0.67	1.33
Shelf Soft	119.00	3.00	39.67	2.00	0.75	0.75	0.50	0.67	1.33
Slope Hard	44.00	3.00	14.67	2.00	0.75	0.75	0.50	0.67	1.33
Slope Soft	86.00	3.00	28.67	2.00	0.75	0.75	0.50	0.67	1.33
Deep Hard	6.00	3.00	2.00	2.00	0.75	0.75	0.50	0.67	1.33
Deep Soft	17.00	3.00	5.67	2.00	0.75	0.75	0.50	0.67	1.33
Replicates of habitats in no-take MPAs									
Coral Reef	56.00	3.00	18.67	2.00	0.50	0.75	0.50	0.58	1.17
Mangroves	17.00	3.00	5.67	2.00	0.50	0.75	0.50	0.58	1.17
Saltmarsh	0.00	3.00	0.00	0.00	0.50	0.75	0.50	0.58	0.00
Seagrass	40.00	3.00	13.33	2.00	0.50	0.75	0.50	0.58	1.17
Seamounts	1.00	3.00	0.33	0.33	0.50	0.75	0.50	0.58	0.19
Shallow Hard	45.00	3.00	15.00	2.00	0.50	0.75	0.50	0.58	1.17
Shallow Soft	39.00	3.00	13.00	2.00	0.50	0.75	0.50	0.58	1.17
Shelf Hard	21.00	3.00	7.00	2.00	0.50	0.75	0.50	0.58	1.17
Shelf Soft	14.00	3.00	4.67	2.00	0.50	0.75	0.50	0.58	1.17
Slope Hard	14.00	3.00	4.67	2.00	0.50	0.75	0.50	0.58	1.17
Slope Soft	9.00	3.00	3.00	2.00	0.50	0.75	0.50	0.58	1.17
Deep Hard	1.00	3.00	0.33	0.33	0.50	0.75	0.50	0.58	0.19
Deep Soft	0.00	3.00	0.00	0.00	0.50	0.75	0.50	0.58	0.00

AVERAGE	**0.94**
	Unlikely

Appendix E. The aggregation table of the connectivity tests

	Subcriteria result	Subcriteria target	Subcriteria ratio (result/target)	Adjusted subcriteria ratio (result/target) (capped at 2)	Uncertainty in data	Uncertainty in target	Uncertainty in method	Average uncertainty	Weighted average of subcriteria (subcriteria ratio x mean uncertainty
Distance between MPAs									
Region	91.06	75.00	1.21	1.21	1.00	0.75	0.50	0.75	0.91
Distance between no-take MPAs									
Region	82.43	75.00	1.10	1.10	0.75	0.75	0.50	0.67	0.73
Distance between MPAs of the same habitat									
Coral Reef	93.25	75.00	1.24	1.24	0.75	0.75	0.50	0.67	0.83
Mangroves	96.59	75.00	1.29	1.29	0.75	0.75	0.50	0.67	0.86
Saltmarshes	99.10	75.00	1.32	1.32	0.75	0.75	0.50	0.67	0.88
Seagrass	90.99	75.00	1.21	1.21	0.75	0.75	0.50	0.67	0.81
Seamounts	68.75	75.00	0.92	0.92	0.75	0.75	0.50	0.67	0.61
Shallow Hard	88.37	75.00	1.18	1.18	0.75	0.75	0.50	0.67	0.79
Shallow Soft	97.68	75.00	1.30	1.30	0.75	0.75	0.50	0.67	0.87
Slope Hard	55.56	75.00	0.74	0.74	0.75	0.75	0.50	0.67	0.49
Slope Soft	81.61	75.00	1.09	1.09	0.75	0.75	0.50	0.67	0.73
Shelf Hard	65.71	75.00	0.88	0.88	0.75	0.75	0.50	0.67	0.58
Shelf Soft	82.50	75.00	1.10	1.10	0.75	0.75	0.50	0.67	0.73
Deep Hard	0.00	75.00	0.00	0.00	0.75	0.75	0.50	0.67	0.00
Deep Soft	44.44	75.00	0.59	0.59	0.75	0.75	0.50	0.67	0.40

AVERAGE	**0.68**
	Unlikely

Appendix F. The aggregation table of the adequacy tests

	Subcriteria result	Subcriteria target	Subcriteria ratio (result/target)	Adjusted subcriteria ratio (result/target) (capped at 2)	Uncertainty in data	Uncertainty in target	Uncertainty in method	Average uncertainty	Weighted average of subcriteria (subcriteria ratio x mean uncertainty
Size of MPAs									
Bahamian	66.07	75.00	0.88	0.88	1.00	0.75	0.50	0.75	0.66
Eastern Caribbean	37.57	75.00	0.50	0.50	1.00	0.75	0.50	0.75	0.38
Florida	62.89	75.00	0.84	0.84	1.00	0.75	0.50	0.75	0.63
Greater Antilles	66.23	75.00	0.88	0.88	1.00	0.75	0.50	0.75	0.66
Guianan	70.97	75.00	0.95	0.95	1.00	0.75	0.50	0.75	0.71
Gulf of Mexico	65.49	75.00	0.87	0.87	1.00	0.75	0.50	0.75	0.65
Southern Caribbean	70.69	75.00	0.94	0.94	1.00	0.75	0.50	0.75	0.71
Southwestern Caribbean	75.00	75.00	1.00	1.00	1.00	0.75	0.50	0.75	0.75
Western Caribbean	82.83	75.00	1.10	1.10	1.00	0.75	0.50	0.75	0.83
Number of no-take MPAs									
Bahamian	8.93	30.00	0.30	0.30	0.75	1.00	1.00	0.92	0.27
Eastern Caribbean	17.68	30.00	0.59	0.59	0.75	1.00	1.00	0.92	0.54
Florida	6.19	30.00	0.21	0.21	0.75	1.00	1.00	0.92	0.19
Greater Antilles	5.26	30.00	0.18	0.18	0.75	1.00	1.00	0.92	0.16
Guianan	0.00	30.00	0.00	0.00	0.75	1.00	1.00	0.92	0.00
Gulf of Mexico	0.00	30.00	0.00	0.00	0.75	1.00	1.00	0.92	0.00
Southern Caribbean	0.00	30.00	0.00	0.00	0.75	1.00	1.00	0.92	0.00
Southwestern Caribbean	9.62	30.00	0.32	0.32	0.75	1.00	1.00	0.92	0.29
Western Caribbean	14.14	30.00	0.47	0.47	0.75	1.00	1.00	0.92	0.43
Percent of MPAs in low impact zones									
Bahamian	99.76	75.00	1.33	1.33	0.75	0.50	0.50	0.58	0.78
Eastern Caribbean	15.05	75.00	0.20	0.20	0.75	0.50	0.50	0.58	0.12

Florida	68.27	75.00	0.91	0.91	0.75	0.50	0.50	0.58	0.53
Greater Antilles	87.86	75.00	1.17	1.17	0.75	0.50	0.50	0.58	0.68
Guianan	95.43	75.00	1.27	1.27	0.75	0.50	0.50	0.58	0.74
Gulf of Mexico	69.69	75.00	0.93	0.93	0.75	0.50	0.50	0.58	0.54
Southern Caribbean	58.31	75.00	0.78	0.78	0.75	0.50	0.50	0.58	0.45
Southwestern Caribbean	85.03	75.00	1.13	1.13	0.75	0.50	0.50	0.58	0.66
Western Caribbean	81.81	75.00	1.09	1.09	0.75	0.50	0.50	0.58	0.64

AVERAGE	**0.48**
	Very unlikely

Appendix G. A list of MPAs considered in the assessment

ID	WDPA ID	PAME assessment?	Name of MPA	No-take	Year of enactment of status	Country code of MPA location	Area within study area (km^2)
1	167051_B	no	Los Tuxtlas	Not Applicable	1998	MEX	8.468
2	306850_B	yes	Sistema Arrecifal Veracruzano	Not Reported	2012	MEX	637.861
3	107837	no	Playa Adyacente a la localidad denominada Río Lagartos	Not Applicable	2002	MEX	3.502
4	306850_A	yes	Sistema Arrecifal Veracruzano	Not Reported	2012	MEX	11.076
5	101430	yes	Laguna de Términos	Not Reported	1994	MEX	3028.535
6	103171	yes	Banco Chinchorro	Not Reported	1996	MEX	1436.680
7	166965	yes	Arrecifes de Cozumel	Not Reported	2000	MEX	122.187
8	71021_A	no	Ría Celestun	Not Applicable	2000	MEX	1.686
9	108073	yes	Sistema Arrecifal Lobos-Tuxpan	Not Reported	2009	MEX	305.455
10	1850_A	yes	Sian Ka'an	Not Applicable	2000	MEX	136.483
11	1850_B	yes	Sian Ka'an	Not Reported	2000	MEX	1397.312
12	20134_B	no	Pantanos de Centla	Not Applicable	1992	MEX	1.426
13	306775_A	yes	Arrecife Alacranes	Not Reported	2000	MEX	314.109
14	306775_B	yes	Arrecife Alacranes	Not Reported	2000	MEX	3020.478
15	306776	yes	Arrecifes de Xcalak	Not Reported	2000	MEX	107.636
16	555587175_A	yes	La porción norte y la franja costera oriental, terrestres y marinas de la Isla de Cozumel	Not Applicable	2012	MEX	5.275
17	306816_B	no	Los Petenes	Not Reported	1999	MEX	1787.165
18	555599633	yes	Arrecifes de Sian Ka'an	Not Reported	1998	MEX	335.860
19	71021_B	no	Ría Celestun	Not Reported	2000	MEX	211.798

20	71022_A	no	Ría Lagartos	Not Applicable	1999	MEX	1.822
21	71022_B	no	Ría Lagartos	Not Applicable	1999	MEX	8.112
22	902281	no	Sian Ka'an	Not Reported	2003	MEX	1869.716
23	478012	no	Parque Nacional Arrecife Alacranes	Not Reported	2008	MEX	3333.793
24	68095	no	Humedal de Importancia para la Conservación de Aves Acuáticas Reserva Río Lagartos	Not Applicable	1986	MEX	9.933
25	900594	no	Dzilam	Not Reported	2000	MEX	202.005
26	902836	no	Laguna de Tamiahua	Not Applicable	2005	MEX	640.126
27	902280	no	Reserva Estatal El Palmar	Not Reported	2003	MEX	83.413
28	902406	no	Parque Nacional Arrecife de Cozumel	Not Reported	2005	MEX	122.203
29	902302	no	Playa Tortuguera X'cacel-X'cacelito	Not Reported	2004	MEX	2.842
30	902305	no	Reserva de la Biosfera Los Petenes	Not Reported	2004	MEX	1786.681
31	902297	no	Parque Nacional Sistema Arrecifal Veracruzano	Not Reported	2004	MEX	516.937
32	902307	no	Área de Protección de Flora y Fauna Laguna de Términos	Not Reported	2004	MEX	3028.504
33	902304	no	Reserva de la Biosfera Banco Chinchorro	Not Reported	2004	MEX	1436.761
34	95351	no	Reserva de la Biosfera Pantanos de Centla	Not Applicable	1995	MEX	1.427
35	902272	no	Parque Nacional Arrecifes de Xcalak	Not Reported	2003	MEX	108.597
36	902293	no	Manglares y humedales de la Laguna de Sontecomapan	Not Reported	2004	MEX	7.505
37	902306	no	Sistema Lagunar Alvarado	Not Applicable	2004	MEX	64.392
38	902284	no	Reserva de la Biosfera Ría Celestún	Not Reported	2004	MEX	210.854
39	555621984	no	Los Petenes	Not Applicable	1996	MEX	681.555
40	555621876	no	Reserva Estatal de Dzilam	Not Applicable	2005	MEX	187.540

41	555621883	no	El Palmar	Not Applicable	1990	MEX	68.016
42	108043	no	Santuario del Manatí, Bahía de Chetumal	Not Applicable	2008	MEX	1264.642
43	20062	no	Sian Ka'an	Not Applicable	1987	MEX	1533.800
44	342400	no	Sandbore	Not Reported	2003	BLZ	4.475
45	555542676	no	Northern Two Cayes	Not Reported	2003	BLZ	3.759
46	342408	no	Dog Flea Caye	Not Reported	2003	BLZ	5.768
47	555582995	no	Maugre Caye Conservation Zone	Not Reported	2012	BLZ	36.041
48	555582996	no	Dog Flea Caye Conservation Zone	Not Reported	2012	BLZ	24.414
49	313431	yes	Swallow Caye	Not Reported	2002	BLZ	30.726
50	301909	yes	Corozal Bay	Not Reported	1998	BLZ	712.937
51	301906	yes	Blue Hole	All	1996	BLZ	4.143
52	555542674	no	Maugre Caye, Turneffe Atoll	Not Reported	2003	BLZ	7.773
53	342404	no	Rocky Point, Ambergris Caye	Not Reported	2003	BLZ	4.799
54	301985	yes	Bacalar Chico	All	1996	BLZ	5.516
55	555582998	no	Blackbird Caye Conservation Zone	Not Reported	2012	BLZ	16.166
56	555582999	no	Vincent's Lagoon Special Management Area	Not Reported	2012	BLZ	18.212
57	555583000	no	Cockroach-Grassy Caye Special Mangement Area	Not Reported	2012	BLZ	8.616
58	555583003	no	Preservation Zone	Not Reported	2012	BLZ	5.653
59	99651	yes	Bacalar Chico	Part	1996	BLZ	54.412
60	301908	yes	Caye Caulker	All	1998	BLZ	38.896
61	555624215	no	Hol Chan	Part	1987	BLZ	51.340
62	12243	yes	Hol Chan	Part	1987	BLZ	390.344
63	555624228	no	Flower Garden Banks	Not Reported	1992	USA	145.677
64	902313	no	Laguna Madre	Not Reported	2004	MEX	1465.856
65	10564	no	Laguna Atascosa National Wildlife Refuge	Not Reported	1949	USA	121.880
66	555610191	no	Spoil Islands	Not Reported		USA	4.381

67	333350	no	Sundown Island	Not Reported		USA	0.117
68	1065	no	Padre Island National Seashore	Not Reported	1962	USA	319.774
69	312121	no	Christmas Bay	Not Reported	1987	USA	18.595
70	555656032	no	Lower Rio Grande Valley	Not Applicable		USA	2.082
71	312187	no	Flower Garden Banks National Marine Sanctuary	Not Reported	1992	USA	145.677
72	3333354	no	Mission-Aransas National Estuarine Research Reserve	Not Reported	2006	USA	446.958
73	333356	no	Aransas National Wildlife Refuge	Not Applicable	1937	USA	34.655
74	375110	no	State	Not Applicable	1911	USA	3.290
75	3333302	no	Welder Flats	Not Reported	1988	USA	3.567
76	555512039	no	Pelican Island	Not Reported		USA	1.112
77	555608956	no	Port Aransas Nature Preserve at Charlie's Pasture	Not Reported		USA	4.410
78	555609852	no	Shamrock Island Fee	Not Reported	1995	USA	0.735
79	555512035	no	Green Island	Not Reported	1923	USA	0.142
80	555512051	no	Lower Rio Grande Valley National Wildlife Refuge	Not Applicable	1979	USA	28.510
81	555661899	no	Bolivar Flats Shorebird	Not Reported		USA	1.436
82	555655910	no	Aransas	Not Applicable	1937	USA	4.493
83	555610094	no	South Bay	Not Reported	1984	USA	13.347
84	555656034	no	Lower Rio Grande Valley	Not Applicable	1979	USA	17.209
85	555614449	no	Atchafalaya Delta Wildlife Management Area and Game Preserve	Not Reported	1977	USA	539.894
86	555655899	no	Padre Island	Not Reported	1962	USA	326.195
87	555655560	no	Boca Chica State Park	Not Reported	1994	USA	1.120
88	555655652	no	Mustang Island State Park	Not Reported	1974	USA	5.374

89	555656022	no	Laguna Atascosa	Not Reported		USA	121.882
90	555661623	no	Isles Dernieres Barrier Islands	Not Reported	1991	USA	3.051
91	555666743	no	Rockefeller	Not Applicable		USA	18.429
92	61706	no	Dry Tortugas National Park	Not Reported	1935	USA	261.214
93	303916	no	Grand Cayman East Grouper Hole	None	1985	GBR	0.888
94	303917	no	Grand Cayman West Grouper Hole	None	2002	GBR	2.845
95	12798	no	Jennifer Bay - Deep Well Marine Park	All	1986	GBR	0.456
96	303912	no	Little Cayman East Grouper Hole	None	1985	GBR	3.212
97	303913	no	Little Cayman West Grouper Hole	None	2002	GBR	1.427
98	12794	no	Mary's Bay - East Point Replenishment Zone	None	1986	GBR	2.847
99	12795	no	South Hole Sound Replenishment Zone	None	1986	GBR	2.403
100	12779	no	South Sound Replenishment Zone	None	1986	GBR	2.726
101	12787	no	West Bay Bight Marine Park	All	1986	GBR	1.438
102	61791	no	Green Cay Marine Park	Not Reported	2015	BHS	8.225
103	12799	no	Bloody Bay Marine Park	All	1986	GBR	1.179
104	303915	no	Cayman Brac West Grouper Hole	None	2002	GBR	1.816
105	303918	no	12-Mile Bank East Grouper Hole	None	2003	GBR	2.578
106	303919	no	12-Mile Bank West Grouper Hole	None	2003	GBR	3.231
107	12777	no	Barkers Replenishment Zone	None	1986	GBR	3.173
108	303914	no	Cayman Brac East Grouper Hole	None	1985	GBR	1.150
109	12790	no	Environmental Zone	All	1986	GBR	8.609
110	12782	no	Frank Sound Replenishment Zone	None	1986	GBR	1.857
111	303905	no	George Town Marine Park	All	1986	GBR	1.874
112	12792	no	Dennis Point Replenishment Zone	None	1986	GBR	0.113
113	12797	no	Dick Sessingers Bay - Beach Point Marine Park	All	1986	GBR	2.055
114	303910	no	No Dive Zone East	None	1986	GBR	1.024
115	303909	no	No Dive Zone West	None	1987	GBR	1.162

116	12780	no	North Sound Replenishment Zone	None	1986	GBR	29.521
117	100837	no	Pageant Beach Replenishment Zone	None	1986	GBR	0.447
118	12800	no	Preston Bay Marine Park	All	1986	GBR	0.815
119	12789	no	Rum Point Marine Park	All	1986	GBR	0.412
120	12784	no	Sand Bluff Replenishment Zone	None	1986	GBR	1.332
121	555600325	no	Sandbar Prohibited Scuba Diving Zone	None	2007	GBR	0.237
122	555600326	no	Sandbar Wildlife Interaction Zone	None	2007	GBR	5.522
123	12788	no	Seven Mile Beach Marine Park	All	1986	GBR	4.814
124	12785	no	Spotter Bay Replenishment Zone	None	1986	GBR	0.333
125	12781	no	Spotts Bay Replenishment Zone	None	1986	GBR	0.155
126	555600328	no	Stingray City Wildlife Interaction Zone	None	2007	GBR	0.352
127	12778	no	West Bay Replenishment Zone	None	1986	GBR	0.691
128	12796	no	White Bay Marine Park	All	1986	GBR	0.159
129	902859	no	Portland Bight Wetlands and Cays	Not Applicable	2006	JAM	3.487
130	902403	yes	Palisadoes - Port Royal	Not Reported	2005	JAM	71.671
131	13675	yes	Bogue Islands Lagoon	Not Reported	1979	JAM	1.657
132	13677	no	Discovery Bay Fish	Not Reported	2009	JAM	0.204
133	555542818	yes	Galleon Harbour	Not Reported	2009	JAM	9.491
134	555542819	no	Oracabessa Fish	Not Reported	2010	JAM	0.806
135	555542820	yes	Three Bay Area	Not Reported	2009	JAM	5.235
136	555542821	yes	Galleon - Black River	Not Reported	2009	JAM	1.872
137	555542822	yes	Bluefields Bay	Not Reported	2009	JAM	15.440
138	555542823	yes	Orange Bay	Not Reported	2009	JAM	5.663
139	555542826	no	Bogue Lagoon Creek	Not Reported	1955	JAM	3.711
140	13676	yes	Negril	Not Reported	1998	JAM	180.679
141	202	yes	Ocho Rios	Not Reported	1996	JAM	132.688
142	36148	no	Healthshire	Not Applicable	1950	JAM	1.651

143	555542900	yes	Salt Harbour (revised)	Not Reported	2009	JAM	8.383
144	14871	yes	Palisadoes	Not Reported	1998	JAM	58.290
145	220101	yes	Portland Bight	Not Reported	1999	JAM	1432.324
146	203	yes	Montego Bay	Part	1992	JAM	12.416
147	168243	yes	Costa Occidental de Isla Mujeres, Punta Cancún y Punta Nizuc	Not Reported	2000	MEX	83.971
148	12884	yes	Isla Contoy	Not Reported	1998	MEX	46.234
149	902275	no	Parque Nacional Isla Contoy	Not Reported	2003	MEX	46.234
150	900569	no	Ciénaga de Zapata	Not Reported	2001	CUB	1492.771
151	900763	no	Buenavista	Not Reported	2002	CUB	2225.071
152	900764	no	Ciénaga de Lanier y Sur de la Isla de la Juventud	Not Reported	2002	CUB	357.887
153	900765	no	Gran Humedal del Norte de Ciego de Ávila	Not Reported	2002	CUB	1419.631
154	900766	no	Humedal Delta del Cauto	Not Applicable	2002	CUB	52.055
155	901221	no	Humedal Río Máximo-Cagüey	Not Reported	2002	CUB	84.316
156	555624218	no	Guanahacabibes	Not Reported	2001	CUB	167.616
157	198297	no	Desembarco del Granma National Park	Not Reported	1999	CUB	64.625
158	41004	no	Abogado Agustín Córdoba Rodríguez (Isla Santanilla o del Cisne)	Not Reported	1991	HND	481.792
159	302864	no	Boca de Canasí	Not Reported	2001	CUB	4.272
160	302591	no	Bahía de Malagueta	Not Reported	2001	CUB	78.096
161	302862	no	Cabo Lucrecia - Punta de Mulas	Not Reported	2001	CUB	38.979
162	36133	no	Bahía de Naranjo	Not Reported	2001	CUB	2.596
163	302851	no	Balsas de Gibara	Not Reported	2001	CUB	1.742
164	168258	no	Caguanes	Not Reported	2001	CUB	115.340
165	302595	no	Caletones	Not Applicable	2001	CUB	6.234
166	302870	no	Cayería de las Cayamas - Los Guzmanes	Not Reported	2010	CUB	374.213

167	317047	no	Cayos Los Ballenatos y manglares de la bahía de Nuevitas	Not Applicable	2001	CUB	2.746
168	13632	no	Cayo Largo	Not Reported	2001	CUB	677.184
169	36107	no	Cayos de Ana María	Not Reported	2001	CUB	178.402
170	302892	no	Cayos de las Cinco Leguas	Not Applicable	2001	CUB	1.902
171	555621483	no	Cayo Mono-Galindo	Not Reported	2010	CUB	164.991
172	302600	no	Correa	Not Reported	2001	CUB	50.175
173	302904	no	Delta del Agabama	Not Reported	2001	CUB	23.270
174	20202	no	Desembarco del Granma	Not Reported	2001	CUB	64.278
175	168267	no	Lanzanillo-Pajonal-Fragoso	Not Reported	2001	CUB	707.471
176	302939	no	Las Loras	Not Reported	2001	CUB	43.215
177	302614	no	Las Picúas-Cayo Cristo	Not Reported	2001	CUB	356.220
178	302976	no	Península de Ramón	Not Reported	2012	CUB	4.968
179	555621479	no	Punta Caribe	Not Applicable	2012	CUB	1.055
180	302631	no	Río Máximo	Not Reported	2001	CUB	84.320
181	302993	no	San Miguel del Junco	Not Reported	2001	CUB	45.754
182	303013	no	Tunas de Zaza	Not Applicable	2001	CUB	3.728
183	302622	no	Punta Francés	Not Reported	2012	CUB	29.146
184	36110	no	Sistema Espeleolacustre de Zapata	Not Reported	2010	CUB	40.517
185	302634	no	Los Caimanes	Not Reported	2008	CUB	285.726
186	302597	no	Cayo Francés	Not Reported	2008	CUB	53.724
187	302609	no	Jardines de la Reina	Not Reported	2010	CUB	1859.920
188	302874	no	Cayo Cruz	Not Reported	2012	CUB	41.304
189	302989	no	Rincón de Guanabo	Not Reported	2012	CUB	4.741
190	302935	no	Laguna del Cobre-Itabo	Not Reported	2012	CUB	5.688
191	20209	no	Hatibonico	Not Reported	2001	CUB	6.577
192	302995	no	Siboney-Juticí	Not Reported	2001	CUB	8.521

193	32359	no	Ciénaga de Zapata	Not Reported	2008	CUB	1303.439
194	302617	no	Maternillos -Tortuguilla	Not Reported	2010	CUB	48.479
195	36123	no	Delta del Cauto	Not Applicable	2001	CUB	57.646
196	306265	no	Sureste de El Inglés	Not Applicable	2008	CUB	9.368
197	168261	no	Guanahacabibes	Not Reported	2001	CUB	167.632
198	302629	no	Peninsula de Guanahacabibes	Not Reported	2001	CUB	588.370
199	302911	no	El Retiro	Not Reported	2010	CUB	3.470
200	302607	no	Humedales de Cayo Romano	Not Reported	2012	CUB	1411.874
201	302873	no	Cayo Campos - Cayo Rosario	Not Reported	2012	CUB	886.191
202	555621494	no	Delta del Mayari	Not Applicable	2012	CUB	1.636
203	555621484	no	El Macio	Not Reported	2012	CUB	126.707
204	555621485	no	Cayos Los Indios	Not Reported	2012	CUB	122.942
205	555621487	no	Macurije-Santa Maria	Not Reported	2012	CUB	97.575
206	555621489	no	Cayo Guajaba	Not Reported	2010	CUB	69.246
207	302844	no	Bacunayagua	Not Reported	2001	CUB	4.160
208	302920	no	Guajimico	Not Reported	2001	CUB	6.917
209	302627	no	Península de Zapata	Not Reported	2008	CUB	2027.821
210	168256	no	Cayos de San Felipe	Not Reported	2010	CUB	241.119
211	302836	no	Laguna de Maya	Not Reported	2010	CUB	2.577
212	555621497	no	Las Nuevas	Not Reported	2012	CUB	5.768
213	555621498	no	Ensenada del Gua y Cayos de Manzanillo	Not Reported	2012	CUB	144.558
214	302619	no	Ojo del Mégano	Not Reported	2010	CUB	4.460
215	32417	no	Bahía de Nuevas Grande - La Isleta	Not Reported	2010	CUB	7.368
216	36101	no	Cayo Santa María	Not Reported	2012	CUB	241.822
217	36099	no	Sur de la Isla de la Juventud	Not Reported	2010	CUB	598.767
218	302854	no	Banco de Buena Esperanza - Managuano	Not Reported	2012	CUB	805.342
219	168265	no	Centro y Oeste de Cayo Coco	Not Reported	2010	CUB	132.776

220	302615	no	Los Pretiles	Not Reported	2012	CUB	336.584
221	555621506	no	Cayo Sabinal	Not Reported	2012	CUB	52.928
222	302850	no	Bahía de Tánamo y cayos	Not Reported	2012	CUB	21.476
223	555621508	no	Ensenada de Rancho Luna	Not Reported	2012	CUB	6.353
224	302875	no	Cayo Levisa- Corona de San Carlos	Not Reported	2012	CUB	171.395
225	555621510	no	Golfo de Batabanó	Not Reported	2012	CUB	793.897
226	555621512	no	Humedal Sur de los Palacios	Not Reported	2012	CUB	140.021
227	555621514	no	Loma de Santa María	Not Reported	2012	CUB	48.520
228	302936	no	Sistema Lagunar La leche - La Redonda	Not Applicable	2012	CUB	1.248
229	555621515	no	Ciénaga de Lanier	Not Reported	2012	CUB	53.606
230	36097	no	Punta del Este	Not Reported	2012	CUB	251.834
231	302628	no	Buenavista	Not Reported	2010	CUB	2260.867
232	302608	no	Humedales del Norte de Ciego de Avila	Not Reported	2010	CUB	1473.119
233	71015	no	Reserva de Biosfera Baconao	Not Applicable	2010	CUB	58.276
234	555621509	no	Banco de San Antonio	Not Reported	2012	CUB	73.923
235	555705334	no	Este del Archipiélago de los Colorados	Not Reported	2020	CUB	492.863
236	555608120	no	Navassa Island National Wildlife Refuge	Not Reported	1999	USA	1468.728
237	555656057	no	Navassa Island	Not Reported		USA	1468.728
238	145524	yes	Gandoca-Manzanillo	Not Reported	1995	CRI	16.581
239	5002	no	Río Plátano Biosphere Reserve	Not Applicable	1982	HND	232.456
240	68135	no	San San-Pond Sak	Not Applicable	1993	PAN	6.533
241	198322	no	Punta de Manabique	Not Reported	2000	GTM	891.752
242	555624229	no	Seaflower	Part	2005	COL	61086.399
243	555637328_B	no	Sistema de Humedales de Santa Elena	Not Reported	2018	HND	6.049
244	555637328_A	no	Sistema de Humedales de Santa Elena	Not Reported	2018	HND	1.368
245	30625	yes	Laguna de Karataska	Not Reported	2002	HND	172.398

246	36053	no	Río Kruta	Not Applicable	2002	HND	1.976
247	555626131	no	Bahía de Tela	Not Reported	2017	HND	861.736
248	36051	no	Laguna de Guaimoreto	Not Applicable	2016	HND	1.511
249	30627	no	Blanca Jeannette Kawas (Punta Sal)	Not Reported	1994	HND	281.668
250	41024	no	Punta Izopo	Not Reported	2000	HND	34.898
251	555582978	yes	Guanaja 2	Not Reported	1961	HND	12.000
252	555582986	no	Cayos Zapotillos	Not Applicable	1992	HND	10.642
253	555582980	no	Laguna de Bacalar	Not Reported	2002	HND	14.459
254	41027	yes	Port Royal	Not Reported	2010	HND	3.851
255	18816	no	Barras de Cuero y Salado	Not Reported	1987	HND	45.403
256	41010	no	Cayos Cochinos	Not Reported	2003	HND	1208.606
257	555582979	no	Islas de la Bahía	Not Reported	2010	HND	6295.697
258	41014	no	Río Plátano	Not Applicable	1980	HND	445.285
259	30622	no	Cayos Misquitos	Not Reported	2014	HND	8991.880
260	555697538	no	Cuyamel	Not Reported	2019	HND	78.887
261	342405	no	Rise and Fall Bank	Not Reported	2003	BLZ	17.214
262	342401	no	Caye Bokel	Not Reported	2003	BLZ	5.583
263	342402	no	South Point	Not Reported	2003	BLZ	5.293
264	220039	yes	Gladden Spit and Silk Cayes	Part	2000	BLZ	103.902
265	99653	yes	Glover's Reef	Part	1993	BLZ	324.341
266	2213	yes	Halfmoon Caye	All	1982	BLZ	39.136
267	34314	yes	Laughing Bird Caye	All	1996	BLZ	40.608
268	342403	no	Seal Caye, Sapodilla Cayes	Not Reported	2003	BLZ	6.480
269	342399	no	Gladden Spit	Not Reported	2003	BLZ	14.891
270	342406	no	Northern Glover's Reef	Not Reported	2003	BLZ	6.385
271	342398	no	Emily or Caye Glory	Not Reported	2003	BLZ	5.470

272	342407	no	Nicholas Caye, Sapodilla Cayes	Not Reported	2003	BLZ	6.481
273	902744	no	Sarstoon Temash National Park	Not Applicable	2005	BLZ	1.053
274	61956	no	Temash-Sarstoon	Not Applicable	1994	BLZ	1.149
275	555583001	no	Caye Brokel Conservation Zone	Not Reported	2012	BLZ	48.039
276	220100	yes	Port Honduras	Part	2000	BLZ	377.132
277	99656	yes	Sapodilla Cayes	Part	1996	BLZ	155.383
278	99652	yes	South Water Caye	Not Reported	1996	BLZ	457.555
279	555624213	no	Port Honduras	Part	2000	BLZ	377.132
280	555624214	no	Glover's Reef	Part	1993	BLZ	324.341
281	900702	no	Refugio de Vida Silvestre Río San Juan	Not Applicable	2001	NIC	2.245
282	555704246	no	Barra del Colorado	Not Reported	2020	CRI	651.297
283	167	yes	Tortuguero	Not Reported	1970	CRI	502.579
284	555698173	no	Cayos Perlas	Not Reported	2010	NIC	1457.168
285	302128	no	Río San Juan	Not Applicable	1999	NIC	2.245
286	30628	no	Río Indio Maíz	Not Applicable	1999	NIC	1.028
287	12667	no	Cayos Miskitos y Franja Costera Inmediata	Not Reported	1991	NIC	5089.038
288	900703	no	Sistema de Humedales de la Bahía de Bluefields	Not Reported	2001	NIC	365.003
289	61075	no	Cerro Silva	Not Applicable	1999	NIC	11.500
290	900699	no	Cayos Miskitos y Franja Costera Inmediata	Not Reported	2001	NIC	5089.502
291	108155	no	Nacional Cariari	Not Reported	1994	CRI	1.123
292	2235	yes	Cahuita	Not Reported	1970	CRI	231.460
293	12493	no	Barra del Colorado	Not Applicable	1985	CRI	8.998
294	19402	no	Gandoca Manzanillo	Not Reported	1985	CRI	57.197

295	315070	no	Río Sarstun	Not Applicable	2005	GTM	1.149
296	12564	yes	Punta de Manabique	Not Reported	2005	GTM	882.608
297	102254	no	San Pond Sak	Not Reported	1994	PAN	134.992
298	107292	no	Donoso	No Applicable	2009	PAN	167.365
299	555705292	no	Portobelo	All	1976	PAN	83.168
300	555705294	no	Reverendo Padre Jesús Héctor Gallego Herrera	Not Reported	2019	PAN	93.763
301	555705295	no	Banco Volcán	Not Reported	2015	PAN	14212.188
302	238	no	Soberanía	No Applicable	1980	PAN	14.101
303	107289	no	Damani-Guariviara	No Applicable	2004	PAN	2.489
304	115101	no	Escudo de Veraguas	All	2009	PAN	417.548
305	107334	no	Narganá	No Applicable	1994	PAN	30.649
306	555705305	no	Playa Bluff	Part	2016	PAN	1.007
307	555705301	no	Zona de Reserva Matumbal	Not Reported	2009	PAN	0.125
308	263	no	Barro Colorado	Not Reported	1977	PAN	9.175
309	555705285	no	Isla Bastimentos	Part	1988	PAN	106.940
310	555705303	no	Islas Advent, Zorra y Juan Gallego	Not Reported	1997	PAN	12.698
311	555705304	no	San Lorenzo	No Applicable	1997	PAN	1.318
312	555592686	yes	Corales de Profundidad	Not Reported	2013	COL	1421.557
313	35271	yes	Old Providence And Mc Bean Lagoon	Not Reported	1995	COL	14.251
314	152	yes	Tayrona	Not Reported	1969	COL	45.333
315	303546	no	El Corchal El Mono Hernandez	Not Applicable	2002	COL	1.226
316	555555868	no	Ensenada de Rionegro, los Bajos Aledanos, las Cienagas de Marimonda y el Salado	Not Reported	2009	COL	43.238
317	555555869	no	Manglar de la Bahia de Cispata y Sector Aledano del Delta Estuarino del Rio Sinu	Not Reported	2006	COL	28.810
318	555555779	no	Jhonny Cay Regional Park	Not Reported	2011	COL	0.385

319	555555714	no	Del Sistema Manglarico del Sector de la Boca de Guacamaya	Not Reported	2008	COL	3.634
320	2234	yes	Los Corales del Rosario y San Bernardo	Not Reported	1977	COL	1214.281
321	555555936	no	Sanguare	Not Reported	2002	COL	2.350
322	555592745	yes	Acandi Playon Y Playona	Not Reported	2013	COL	254.759
323	555636411	no	Area Marina Protegida de la Reserva de Biosfera Seaflower	Not Reported	2005	COL	61086.399
324	126	yes	Los Flamencos	Not Reported	1977	COL	8.470
325	150	yes	Isla de Salamanca	Not Reported	1969	COL	248.163
326	365668	no	Bayou Sauvage	Not Applicable	1992	USA	1.331
327	365317	no	Apalachicola River Wildlife and Environmental Area	Not Applicable	1974	USA	2.032
328	1064	no	Gulf Islands National Seashore	Not Reported	1971	USA	411.362
329	2860	no	Delta National Wildlife Refuge	Not Applicable	1935	USA	2.169
330	2861	no	Breton National Wildlife Refuge	Not Reported	1904	USA	52.796
331	21059	no	Weeks Bay National Estuarine Research Reserve	Not Reported	1986	USA	14.104
332	352713	no	Hancock County Marsh Coastal Preserve	Not Applicable	1992	USA	2.487
333	352714	no	Jourdan River Coastal Preserve	Not Reported	1992	USA	6.416
334	352716	no	Pascagoula River Marsh Coastal Preserve	Not Applicable	1992	USA	8.062
335	352723	no	Grand Bay Savannah Coastal Preserve	Not Applicable	1992	USA	2.676
336	375080	no	St. Joseph Bay State Buffer Preserve	Not Applicable	1995	USA	1.126
337	6666345	no	Davis Bayou Coastal Preserve	Not Reported	1992	USA	1.750
338	555586746	no	Fort Pickens State Park Aquatic Preserve	Not Reported	1970	USA	119.047
339	555586752	no	Rocky Bayou State Park Aquatic Preserve	Not Reported	1970	USA	0.966
340	555586753	no	St. Andrews State Park Aquatic Preserve	Not Reported	1972	USA	93.538

341	555586754	no	St. Joseph Bay Aquatic Preserve	Not Reported	1969	USA	258.453
342	555586759	no	Yellow River Marsh Aquatic Preserve	Not Reported	1970	USA	26.790
343	555586813	no	Grand Bay National Estuarine Research Reserve	Not Reported	1999	USA	16.310
344	555586819	no	USS Massachusetts (BB-2) Underwater Archaeological Preserve	Not Reported	1993	USA	0.282
345	555586821	no	SS Tarpon Underwater Archaeological Preserve	Not Reported	1997	USA	0.783
346	555586824	no	Vamar Underwater Archaeological Preserve	Not Reported	2004	USA	0.783
347	555586900	no	Apalachicola Bay Aquatic Preserve	Not Reported	1969	USA	288.373
348	555655897	no	Gulf Islands	Not Reported	1971	USA	194.922
349	555655554	no	Bayou Savage National Wildlife Refuge	Not Applicable	1986	USA	1.331
350	555661990	no	St. Joseph Bay	Not Applicable	1995	USA	1.126
351	555625733	no	Hogsty Reef Protected Area	Not Reported	2015	BHS	49.404
352	555625732	no	Southeast Bahamas Marine Managed Area	Not Reported	2015	BHS	24337.830
353	555625731	no	Bight of Acklins National Park	Not Reported	2015	BHS	246.029
354	555624132	no	Humedales de Jaragua	Not Reported	2014	DOM	209.117
355	315000	yes	Little Inagua National Park	Not Reported	2002	BHS	84.234
356	555624212	no	Saba	Part	1987	NLD	8.721
357	317034	no	Saba	Not Reported	1998	NLD	0.144
358	220029	no	St. Eustatius (Statia)	Part	1996	NLD	21.272
359	2187	yes	Conception Island National Park	Not Reported	1964	BHS	92.268
360	555592586	yes	Jewfish Cay Marine Reserve	All	2009	BHS	120.649
361	24	no	Inagua National Park	Not Applicable	1997	BHS	4.561
362	11839	yes	Pelican Cays Land And Sea Park	All	1972	BHS	8.195
363	315003	yes	Moriah Harbour Cay National Park	Not Reported	2002	BHS	86.256
364	555592841	yes	No Name Cay Marine Reserve	Not Reported	2010	BHS	3.297
365	555592579	yes	Fowl Cays National Park	Not Reported	2009	BHS	4.725

366	145515	no	Inagua National Park	Not Applicable	1997	BHS	4.561
367	555625727	no	East Abaco Creeks - The Bight	Not Reported	2015	BHS	9.661
368	555625726	no	East Abaco Creeks - Snake Cays	Not Reported	2015	BHS	5.709
369	555625725	no	Booby Cay National Park	Not Reported	2015	BHS	0.195
370	555625721	no	East Abaco Creeks - Cherokee	Not Reported	2015	BHS	11.201
371	555625719	yes	West Coast Dive Site	Not Reported	2015	BHS	36.952
372	555625718	yes	Greens Bay National Park	Not Reported	2015	BHS	1.941
373	555625717	yes	Graham's Harbour	Not Reported	2015	BHS	22.508
374	555625715	yes	Pigeon Creek & Snow Bay National Park	Not Reported	2015	BHS	12.496
375	555624222	no	La Caleta	Not Reported	1986	DOM	8.378
376	555624220	no	Jaragua	Not Reported	1983	DOM	865.427
377	555547980	no	Saint-Martin	Not Reported	2012	FRA	30.176
378	555587042	no	Saint-Martin	Not Reported	2012	FRA	30.180
379	18780	no	Long Cay	Not Reported	1987	GBR	0.428
380	317043	no	St Maarten	Not Reported	1997	NLD	16.672
381	555624206	no	Man o War Shoal Marine Park	Part	2010	NLD	16.672
382	68305	no	North, Middle & East Caicos Islands	Not Reported	1990	GBR	55.581
383	13976	no	Big Sand Cay	Not Reported	1987	GBR	0.970
384	18778	no	Vine Point and Ocean Hole	Not Reported	1987	GBR	7.161
385	13980	no	Fort George Land and Sea	Not Reported	1987	GBR	3.713
386	18779	no	Bell Sound	Not Reported	1975	GBR	9.769
387	18781	no	Three Mary Cays	Not Reported	1987	GBR	0.153
388	18784	no	North West Point Marine	Not Reported	1987	GBR	9.221
389	18786	no	East Bay Islands	Not Reported	1987	GBR	13.369
390	31287	no	Pigeon Pond and Frenchman's Creek	Not Reported	1992	GBR	3.633
391	31295	no	West Caicos Marine	Not Reported	1992	GBR	3.183
392	31304	no	Admiral Cockburn Land And Sea	Not Reported	1992	GBR	1.885
393	36095	no	Admiral Cockburn	Not Reported	1992	GBR	1.269

394	36094	no	Columbus Landfall Marine	Not Reported	1992	GBR	3.459
395	12832	no	Grand Turk Cays, Land and Sea	Not Reported	1987	GBR	1.083
396	36093	no	Princess Alexandra Land and Sea	Not Reported	1992	GBR	24.302
397	61698	no	North, Middle and East Caicos	Not Reported	1992	GBR	65.353
398	555643716	no	Les Trois Baies	Part	2014	HTI	528.778
399	555643718	no	Port Salut-Aquin	Not Reported	2013	HTI	704.588
400	14078	no	Guana Is.	All		GBR	0.106
401	31308	no	Horseshoe Reef	All		GBR	37.245
402	14215	no	Great Dog	None		GBR	0.125
403	14076	no	Great Carrot Bay	None		GBR	0.227
404	12902	no	Anegada north	None		GBR	6.692
405	14551	no	Dead Chest to James George Bay	None		GBR	8.234
406	12837	no	Dogs Marine Area	None		GBR	10.135
407	14214	no	Ginger Island	None		GBR	2.146
408	12839	no	Jost Van Dyke	None		GBR	0.830
409	14219	no	Mosquito Island	None		GBR	0.157
410	12840	no	Norman Island	All		GBR	2.092
411	14221	no	Peter Island	All		GBR	3.667
412	12841	no	Prickly Pear	All		GBR	1.027
413	78	no	RMS Rhone	All	1980	GBR	2.590
414	14210	no	Salt and Cooper Is	All		GBR	2.641
415	555624396	no	Beef Island	All		GBR	0.864
416	555624392	no	Eastern Ponds	None		GBR	1.149
417	555624414	no	Long Bay Beef Isl	None		GBR	0.146
418	555624400	no	Anegada south west	All		GBR	0.950
419	555624421	no	Anegada west	None		GBR	3.745
420	555624393	no	Beef Island	All		GBR	0.294
421	555624402	no	Ginger Island	All		GBR	0.267
422	555624404	no	Great Harbour	None		GBR	1.513

423	555624405	no	Great Thatch	None		GBR	0.819
424	555624410	no	Great Thatch	All		GBR	0.339
425	555624422	no	Green Cay, Sandy Cay, Sandy Spit	All		GBR	3.000
426	555624425	no	Lee Bay	None		GBR	0.139
427	555624432	no	Norman Island	None		GBR	0.675
428	555624436	no	Scrub Island	None		GBR	1.433
429	555624407	no	Virgin Gorda	None		GBR	13.805
430	555624423	no	Tobagos	None		GBR	3.951
431	555624430	no	Tortola	None		GBR	0.169
432	555624433	no	Tortola	None		GBR	1.467
433	555624437	no	Virgin Gorda	All		GBR	0.566
434	555624412	no	Virgin Gorda	All		GBR	0.313
435	555624431	no	Virgin Gorda north	All		GBR	14.051
436	555624413	no	Virgin Gorda South	None		GBR	9.409
437	478141	no	Sierra Martín García	Not Applicable	2004	DOM	11.654
438	555629477	no	La Hispaniola	Not Reported	2009	DOM	25.561
439	555629472	no	Francisco Alberto Caamaño Deñó	Not Reported	2009	DOM	290.164
440	555629458	no	Boca de Nigua	Not Reported	2009	DOM	2.811
441	478077	no	Bahía de las Águilas	Not Reported	2004	DOM	16.128
442	555629480	no	Laguna Gri-Grí	Not Reported	2009	DOM	14.596
443	555629493	no	Punta Espada	Not Applicable	2009	DOM	1.039
444	478100	yes	Isla Catalina	Not Reported	2004	DOM	6.228
445	6674	yes	Submarino Monte Cristi	Not Reported	2004	DOM	237.036
446	478125	no	Manglares de Estero Balsa	Not Applicable	2004	DOM	1.740
447	478102	yes	Submarino La Caleta	Not Reported	2004	DOM	8.024
448	478122	no	Manglar de la Jina	Not Reported	2004	DOM	35.925
449	478103	no	La Gran Laguna o Perucho	Not Reported	2004	DOM	3.008

450	478123	no	Manglares de Puerto Viejo	Not Reported	2004	DOM	4.249
451	478070	no	Bahia de Luperón	Not Reported	2004	DOM	5.062
452	6673	yes	Jaragua	Not Reported	2004	DOM	813.441
453	180	yes	Cotubanamá (Del Este)	Not Reported	2014	DOM	376.547
454	478082	no	Cayos Siete Hermanos	Not Reported	2004	DOM	113.974
455	555629450	no	Arrecifes del Sureste	Not Reported	2009	DOM	7838.109
456	555629501	no	Playa Larga	Not Reported	2004	DOM	6.122
457	555629490	no	Playa Blanca	Not Reported	2004	DOM	1.199
458	478087	no	Vía Panorámica Costa Azul	Not Reported	2004	DOM	14.587
459	555629467	no	Cayo Terreno	Not Reported	2004	DOM	0.151
460	555629474	no	Gran Estero	Not Reported	2009	DOM	124.421
461	478098	no	Humedales del Bajo Yaque del Sur	Not Reported	2004	DOM	17.794
462	478092	yes	Estero Hondo	Not Reported	2004	DOM	9.327
463	478071	no	Santuario de los Bancos de La Plata y La Navidad	Not Reported	2004	DOM	35298.609
464	555629499	no	Santuario Marino del Norte	Not Reported	2014	DOM	242.819
465	555643708	no	Baradéres-Cayemites	Not Reported	2017	HTI	448.764
466	555643709	no	Jérémie-Abricots	Not Reported	2017	HTI	69.289
467	555643713	no	Lagon des Huîtres	Not Reported	2017	HTI	29.740
468	555643719	no	La Cahouane	None	2013	HTI	22.171
469	555587195	no	Palaster Reef Sanctuary	All	2014	ATG	22.610
470	555587196	no	Goat Point Sanctuary	All	2014	ATG	18.199
471	555587197	no	Low Bay Sanctuary	All	2014	ATG	45.429
472	902698	no	Codrington Lagoon	None	2005	ATG	16.162
473	555587198	no	Two Foot Bay Sanctuary	All	2014	ATG	48.439
474	2	no	Palaster Reef	All	1973	ATG	3.833
475	555587194	yes	Codrington Lagoon	Not Reported	2005	ATG	21.916
476	147314	no	Saint-Barthélemy	Not Reported	1996	FRA	9.617
477	193403	no	Saint-Martin	Not Reported	1998	FRA	30.152

478	302604	no	Esparto	Not Applicable	2001	CUB	1.923
479	302950	no	Macambo	Not Reported	2001	CUB	3.245
480	302594	no	Maisí - Caleta	Not Reported	2001	CUB	21.823
481	302951	no	Maisí-Yumurí	Not Reported	2001	CUB	12.319
482	36127	no	Tacre	Not Applicable	2012	CUB	1.883
483	555621482	no	Yara-Majayara	Not Reported	2012	CUB	2.566
484	342	yes	Virgin Islands National Park	Not Reported	1956	USA	20.389
485	1047	no	Buck Island Reef National Monument	Not Reported	1961	USA	75.910
486	12438	no	Isla de Mona Natural Reserve	Not Reported	1986	USA	1511.392
487	31503	no	Hacienda La Esperanza Natural Reserve	Not Reported	1987	USA	50.633
488	31504	no	Cabezas de San Juan Natural Reserve	Not Reported	1975	USA	304.267
489	31506	no	Punta Yegüas Natural Reserve	Not Reported	1975	USA	262.166
490	88887	no	Jobos Bay National Estuarine Research Reserve	Not Reported	1981	USA	6.406
491	302299	no	Punta Petrona Natural Reserve	Not Reported	1985	USA	29.936
492	302300	no	Río Espíritu Santo Natural Reserve	Not Reported	2001	USA	84.961
493	301922	no	Salt River Bay National Historic Park and Ecological Preserve	Not Reported	1992	USA	2.430
494	302289	no	Arrecifes de la Cordillera Natural Reserve	Not Reported	1980	USA	98.264
495	302293	no	Cueva del Indio Natural Reserve	Not Reported	1992	USA	15.573
496	888834	no	Bosque Estatal De Boquerón	Not Reported		USA	2.119
497	888823	no	Punta Guaniquilla Natural Reserve	Not Reported	1976	USA	80.112
498	888820	no	Bahías Bioluminiscentes de Vieques Natural Reserve	Not Reported	1989	USA	78.627
499	888827	no	La Parguera Natural Reserve	Not Reported	1979	USA	315.610
500	888833	no	Bosque Estatal de Aguirre	Not Reported	1983	USA	1.819
501	888837	no	Bosque Estatal de Ceiba Natural Reserve	Not Reported	1979	USA	1.844
502	888840	no	Bosque Estatal de Guánica Natural Reserve	Not Reported	1985	USA	11.405

503	888843	no	Bosque Estatal de Piñones Natural Reserve	Not Reported	1918	USA	1.120
504	555512153	no	Tres Palmas de Rincón Marine Reserve	Not Reported	2004	USA	0.377
505	555512159	no	Isla de Desecheo Marine Reserve	Not Reported	2000	USA	5.592
506	555547387	no	Canal Luis Peña Natural Reserve	Not Reported	1999	USA	5.836
507	555662042	no	Punta Petrona	Not Reported		USA	1.118
508	555586709	no	Bosque Natural de Boquerón Natural Reserve	Not Reported	1998	USA	152.559
509	555586710	no	Arrecifes de Guayama Natural Reserve	Not Reported	1980	USA	4.414
510	555586711	no	Arrecifes de Tourmaline Natural Reserve	Not Reported	1998	USA	72.687
511	555586712	no	St. Croix East End Marine Park	Not Reported	2003	USA	146.925
512	555586828	no	Virgin Islands Coral Reef National Monument	Not Reported	2001	USA	50.880
513	555586835	no	St. Thomas East End Reserves	Not Reported	2011	USA	7.646
514	555655870	no	Virgin Islands	Not Reported		USA	20.196
515	555655568	no	Caja de Muertos Natural Reserve	Not Reported	1981	USA	123.048
516	555655584	no	Cas Cay-Mangrove Lagoon Marine Reserve & Wildlife Sanctuary	Not Reported	1994	USA	1.856
517	555662024	no	Isla de Mona	Not Applicable		USA	1.519
518	555662944	no	Bosque Estatal De Aguirre	Not Reported		USA	1.792
519	555662945	no	Bosque Estatal De Ceiba	Not Reported		USA	0.623
520	32637	no	Sandy Island	None	1993	GBR	4.669
521	555705843	no	Little Bay	None	1993	GBR	0.436
522	14075	no	Shoal Bay and Island Harbour Reefs	None	2007	GBR	11.934
523	32636	no	Prickly Pear Cays and Seal Island Reefs	None	1993	GBR	29.229
524	32638	no	Dog Island	None	1993	GBR	6.225
525	32641	no	Sombrero Island Nature Reserve	None	1993	GBR	9.896
526	555637442	no	Sombrero Island Nature Reserve Marine Park	None	2018	GBR	9.896
527	555585400	no	Big Hickory Island	Not Reported		USA	0.446

528	2854	no	Pinellas National Wildlife Refuge	Not Reported	1951	USA	0.817
529	21116	no	J.N. Ding Darling National Wildlife Refuge	Not Reported	1945	USA	4.316
530	555583666	no	The Kitchen	Not Reported		USA	0.775
531	666646	no	Estero Bay Preserve State Park	Not Applicable	1987	USA	2.766
532	666639	no	Charlotte Harbor Preserve State Park	Not Applicable	1970	USA	4.391
533	6666113	no	Passage Key National Wildlife Refuge	Not Reported	1905	USA	0.238
534	555656011	no	J.N. Ding Darling	Not Applicable		USA	1.234
535	555583438	no	Cabbage	Not Reported		USA	1.041
536	555585615	no	Shell Key	Not Reported		USA	5.373
537	555585545	no	Neal	Not Reported		USA	0.171
538	555658255	no	Estero Bay	Not Applicable	1987	USA	2.603
539	555586749	no	Matlacha Pass Aquatic Preserve	Not Reported	1972	USA	43.853
540	555586750	no	Pine Island Sound Aquatic Preserve	Not Reported	1970	USA	199.858
541	555586762	no	Cockroach Bay Aquatic Preserve	Not Reported	1976	USA	9.255
542	555586745	no	Estero Bay Aquatic Preserve	Not Reported	1966	USA	26.774
543	555586747	no	Gasparilla Sound - Charlotte Harbor Aquatic Preserve	Not Reported	1979	USA	321.948
544	555586748	no	Lemon Bay Aquatic Preserve	Not Reported	1986	USA	21.291
545	555586756	no	Cape Haze Aquatic Preserve	Not Reported	1975	USA	39.677
546	555586758	no	Terra Ceia Aquatic Preserve	Not Reported	1983	USA	76.479
547	555586820	no	SS Copenhagen Underwater Archaeological Preserve	Not Reported	1994	USA	0.125
548	555606600	no	J. N. Ding Darling National Wildlife Refuge	Not Applicable	1977	USA	1.141
549	555656079	no	Passage Key	Not Reported		USA	0.162
550	555658252	no	Charlotte Harbor	Not Applicable	1970	USA	4.122
551	555655561	no	Boca Ciega Bay Aquatic Preserve	Not Reported	1969	USA	59.636

552	555656087	no	Pinellas	Not Reported	1951	USA	0.807
553	68310	no	Everglades National Park	Not Reported	1987	USA	2013.232
554	555624225	no	Everglades	Part	1934	USA	2057.492
555	2012	yes	Everglades National Park	Not Reported	1979	USA	2075.187
556	13019	no	National Key Deer Refuge	Not Reported	1954	USA	281.425
557	555585915	no	Cowpens	Not Reported		USA	0.753
558	13020	no	Key West National Wildlife Refuge	Not Reported	1908	USA	840.285
559	971	yes	Everglades National Park	Not Reported	1934	USA	2057.493
560	1024	yes	Biscayne National Park	Not Reported	1968	USA	666.007
561	9299	no	John Pennekamp Coral Reef State Park	Not Reported	1959	USA	235.407
562	13090	no	Rookery Bay National Estuarine Research Reserve	Not Reported	1978	USA	188.012
563	13792	no	Great White Heron National Wildlife Refuge	Not Reported	1938	USA	506.384
564	555607478	no	Marjory Stoneman Douglas	Not Reported	1978	USA	2039.339
565	168254	no	Ten Thousand Islands National Wildlife Refuge	Not Reported	1996	USA	35.475
566	555612295	no	Windley Key Fossil Reef Geological	Not Reported	1986	USA	0.543
567	555547377	no	San Pedro Underwater Archaeological Preserve	Not Reported	1989	USA	3.128
568	555583160	no	Lignumvitae Key Botanical State Park	Not Reported	1971	USA	39.930
569	555652733	no	San Pedro Underwater	Not Reported	1989	USA	2.605
570	555586757	no	Coupon Bight Aquatic Preserve	Not Reported	1969	USA	16.216
571	555586760	no	Cape Romano - Ten Thousand Islands Aquatic Preserve	Not Reported	1969	USA	89.053
572	555586771	no	Lignumvitae Key Aquatic Preserve	Not Reported	1969	USA	33.020
573	555586822	no	Half Moon Underwater Archaeological Preserve	Not Reported	2000	USA	0.782
574	555586901	no	Rookery Bay Aquatic Preserve	Not Reported	1975	USA	100.979
575	555665411	no	Key West National Wildlife Refuge	Not Reported	1977	USA	3.050

576	555655992	no	Great White Heron	Not Reported	1938	USA	783.350
577	555655803	no	Rookery Bay	Not Reported	1978	USA	197.598
578	555661938	no	Rookery Bay National Estuarine Sanctuary Macrosite	Not Reported	1969	USA	0.113
579	555609649	no	San Pedro Underwater Archaeological Preserve State Park	Not Reported	1989	USA	2.605
580	555653234	no	Lignumvitae Key	Not Reported	1971	USA	40.065
581	555655851	no	Everglades	Not Reported	1934	USA	2057.493
582	555655847	no	Biscayne	Not Reported	1980	USA	665.715
583	555655558	no	Biscayne Bay-Card Sound Spiny Lobster Sanctuary	Not Reported	1984	USA	491.327
584	555655559	no	Biscayne Bay Aquatic Preserve	Not Reported	1974	USA	253.888
585	555656019	no	Key West	Not Reported	1908	USA	851.572
586	555661628	no	National Key Deer	Not Applicable		USA	2.009
587	555662485	no	Curry Hammock	Not Reported	1991	USA	1.135
588	555625729	no	Cross Harbour National Park	Not Reported	2015	BHS	42.596
589	555592584	yes	South Berry Islands Marine Reserve	Part	2008	BHS	202.184
590	555592582	yes	Andros Northern Marine Park	Not Reported	2002	BHS	16.643
591	555592583	yes	Andros Southern Marine Park	Not Reported	2002	BHS	11.607
592	61790	no	Joulter Cays National Park	Not Reported	2015	BHS	363.386
593	555625723	no	Southwest New Providence Marine Managed Area	Not Reported	2015	BHS	70.671
594	1073	no	Cumberland Island National Seashore	Not Reported	1972	USA	13.249
595	555586766	no	Fort Clinch State Park Aquatic Preserve	Not Reported	1970	USA	29.203
596	555586767	no	Guana River Marsh Aquatic Preserve	Not Reported	1984	USA	100.754
597	555585532	no	Timucuan Ecological & Historic Preserve	Not Applicable	1988	USA	5.230
598	555662521	no	Little Talbot Island	Not Reported	1950	USA	1.222
599	555586774	no	Nassau River - St. Johns River Marshes Aquatic Preserve	Not Reported	1969	USA	82.268

600	230	no	Bonaire	Not Reported	1979	NLD	16.668
601	68113	no	Klein Bonaire Island & adjacent sea	Not Reported	1980	NLD	1.730
602	68111	no	Het Lac	Not Reported	1980	NLD	5.891
603	68112	no	Het Pekelmeer	Not Reported	1980	NLD	2.290
604	27	no	Folkstone	All	1980	BRB	9.930
605	98097	no	Carslisle Bay	Not Reported		BRB	2.237
606	555563757	no	Malpais/Sint Michiel	Not Reported	2013	NLD	1.395
607	555558370	no	Rif Sint Marie	Not Reported	2013	NLD	1.498
608	9712	no	Oostpunt	Not Reported	1983	NLD	7.245
609	11844	no	Cabrits	Not Reported	1987	DMA	2.247
610	37117	no	Soufriere/Scott's Head	Not Reported	1998	DMA	1.676
611	555587043	no	Petite Terre	Not Reported	2012	FRA	8.178
612	103548	no	Grand Cul-de-Sac Marin de la Guadeloupe	Not Reported	1993	FRA	181.536
613	555587038	no	Guadeloupe	Not Reported	2010	FRA	1329.686
614	94070	no	Basse-Mana	Not Reported	1993	FRA	130.620
615	94071	no	Marais De Kaw	Not Reported	1993	FRA	695.820
616	555587039	no	Île du Grand Connétable	Not Reported	2010	FRA	76.385
617	109023	no	Estuaire du fleuve Sinnamary	Not Reported	2008	FRA	275.433
618	555593014	no	Pitons(Qualibou and Canaries)	Not Reported		LCA	14.185
619	555592994	no	Iyanola and Grande Anses, Esperance and Fond D'ors	Not Reported		LCA	14.320
620	555592997	no	East Coast and Praslin	Not Reported		LCA	3.783
621	555592998	no	East Coast (incl. Fond D'Or, Grand Anse, Cas En Bas, Marquis, Esperance Harbour and Louvette Marine Reserves)	Not Reported		LCA	12.222
622	555592999	no	East Coast	Not Reported		LCA	5.120
623	97472	no	Vigie	Not Reported		LCA	0.207
624	555593000	no	East Coast	Not Reported		LCA	0.875
625	32726	no	Anse Cochon	Not Reported	1990	LCA	1.552

626	555593002	no	Laborie	Not Reported		LCA	1.374
627	555593003	no	West Coast (incl. Anse la Raye/Canaries Local Fisheries Management Area)	Not Reported	1998	LCA	1.728
628	555593004	no	Mandelé	Not Reported		LCA	4.305
629	555593006	no	East Coast	Not Reported		LCA	6.952
630	555593007	no	West Coast (incl. Anse la Raye/Canaries Local Fisheries Management Area and Marigot Bay)	Not Reported	1998	LCA	3.995
631	555593008	no	West Coast (incl. Soufriere, Rachette Reefs, Petit Piton, Gros Piton and Anse Chastenets)	Not Reported	1995	LCA	13.946
632	555593009	yes	Pointe Sable	Not Reported	2007	LCA	9.710
633	555593010	no	West Coast (incl. Anse la Raye/Canaries Local Fisheries Management Area and Anse Cochon, Anse Galet and Anse la Verdures)	Not Reported	1998	LCA	2.553
634	555593011	no	Cold Upwelling	Not Reported		LCA	310.351
635	312884	no	The Maria Islet Reef	Not Reported	1986	LCA	0.347
636	32729	no	Moule a Chique	Not Reported	1990	LCA	0.394
637	32730	no	Ceasar-Mathurin	Not Reported	1990	LCA	0.373
638	902367	yes	Pitons Management Area	Not Reported	2004	LCA	3.355
639	280	yes	Wia-Wia	Not Reported	1961	SUR	84.120
640	282	yes	Galibi	Not Reported	1969	SUR	7.316
641	12186	no	Peruvia	Not Applicable	1986	SUR	3.273
642	281	yes	Coppename Monding	Not Reported	1966	SUR	131.623
643	303890	yes	Noord Coronie	Not Reported		SUR	291.505
644	13651	yes	Bigi Pan	Not Reported	1987	SUR	809.445
645	303889	yes	North Commewijne - Marowijne	Not Reported		SUR	1330.215
646	303892	yes	Noord Saramacca	Not Reported		SUR	640.100
647	32663	no	Little Tobago	Not Applicable	1928	TTO	1.751

648	12709	no	Buccoo Reef	Not Reported	1970	TTO	7.487
649	26480	no	Union-Palm Island	Not Reported	1987	VCT	10.081
650	31478	yes	Tobago Cays-Mayreau	Not Reported	1987	VCT	48.866
651	31466	no	Bequia Marine	Not Reported	1987	VCT	2.259
652	26479	yes	Petit St. Vincent	Not Reported	1987	VCT	1.146
653	26477	no	Petit Canouan	Not Reported	1987	VCT	0.181
654	26469	no	Battowia Island	Not Reported	1987	VCT	0.318
655	555576492	no	Canouan	Not Reported		VCT	8.487
656	555576498	no	Mustique	Not Reported		VCT	5.163
657	555576505	no	South Coast	Not Reported		VCT	1.046
658	555576499	no	Mustique	Not Reported		VCT	1.194
659	26475	no	Isle Quatre	Not Reported	1987	VCT	2.123
660	555576490	no	Balliceaux Island	Not Reported		VCT	0.812
661	555624230	no	Tobago Cays-Mayreau	Not Reported	1987	VCT	48.866
662	555637439	no	Klein Curaçao	Not Reported	2018	NLD	1.215
663	555681933	no	Redonda	Part		ATG	298.388
664	555587193	no	Cades Bay	All	1999	ATG	16.756
665	1	no	Diamond Reef and Salt Fish Tail Reef	All	1973	ATG	14.588
666	31517	no	Devil's Bridge	None	2008	ATG	0.415
667	31518	no	Northeast Marine Management Area	Part	2005	ATG	93.404
668	555587192	yes	Nelson's Dockyard	Part	1989	ATG	16.486
669	555576149	no	Fort Barrington	None	2008	ATG	0.144
670	41057_A	yes	Shell Beach Protected Area	Not Applicable	2011	GUY	17.220
671	41057_B	yes	Shell Beach Protected Area	Not Reported	2011	GUY	8.469
672	555546406	no	Ilots De Sainte Rose	Not Reported	2010	FRA	0.183
673	392080	no	Rivages De Vieux Habitants	Not Reported	2003	FRA	0.187
674	147324	no	Pointe Des Chateaux	Not Reported	1987	FRA	0.250
675	392099	no	Pointe De Miquelon Gros Cap	Not Reported	2003	FRA	0.102

676	330602	no	Le Chameau	Not Reported	2000	FRA	0.328
677	555546430	no	Petit Cayenne	Not Reported	2008	FRA	5.294
678	147333	no	Crique Et Pripri Yiyi	Not Reported	1995	FRA	269.346
679	391977	no	Rivages De Cayenne	Not Reported	1983	FRA	0.172
680	193408	no	Guyane	Not Applicable	2001	FRA	370.144
681	392035	no	Ilet A Cabrits	Not Reported	2007	FRA	0.353
682	147297	no	Guadeloupe	Not Reported	1989	FRA	31.028
683	147298	no	Guadeloupe [Aire D'Adhésion]	Not Reported	1989	FRA	1291.814
684	330603	no	Ilet Kahouanne	Not Reported	2000	FRA	0.192
685	392090	no	Bois Jolan - Pointe Du Vent	Not Reported	2003	FRA	0.559
686	193402	no	Iles De La Petite Terre	Not Reported	1998	FRA	8.178
687	555546427	no	Rivages De Bouillante	Not Reported	2008	FRA	0.268
688	147307	no	Terre-De-Haut	Not Reported	1991	FRA	2.168
689	147310	no	Ilets De Petite Terre	Not Reported	1994	FRA	0.869
690	392072	no	Anse A La Barque	Not Reported	2003	FRA	0.139
691	392086	no	Rivages De Capesterre De Marie Galante	Not Reported	2003	FRA	0.199
692	555546408	no	Ilet Fajou	Not Reported	2010	FRA	0.645
693	392073	no	Gros Morne - Grande Anse	Not Reported	2003	FRA	0.171
694	392100	no	Morne Paquette - Pointe Sud	Not Reported	2003	FRA	0.126
695	147330	no	Grand Ilet Des Saintes	Not Reported	1994	FRA	0.318
696	147328	no	Iles De La Petite Terre	Not Reported	1991	FRA	0.470
697	392070	no	Pointe Canot	Not Reported	2003	FRA	0.124
698	392102	no	Beausejour Blondeau	Not Reported	2003	FRA	0.119
699	392110	no	Mangrove De Petit Canal A Port Louis	Not Reported	2003	FRA	2.224
700	555546404	no	Anse A Saints	Not Reported	2003	FRA	0.221
701	147521	no	Marais De Kaw-Roura	Not Reported	1998	FRA	301.775
702	555589798	no	Pointe Liberte	Not Reported	2015	FRA	0.821

703	147520	no	L'Amana	Not Applicable	1998	FRA	8.496
704	555561961	no	Rive Droite Du Mahury	Not Reported	2013	FRA	24.814
705	147315	no	Grand Matoury	Not Applicable	1994	FRA	1.139
706	147302	no	Ile Du Grand-Connétable	Not Reported	1992	FRA	76.783
707	345890	no	Mont Grand Matoury	Not Applicable	2006	FRA	1.135
708	392040	no	Piste De L'Anse	Not Reported	2008	FRA	17.694
709	330598	no	Montagne D'Argent	Not Reported	1998	FRA	1.367
710	555589799	no	Habitation Vidal	Not Reported	2015	FRA	1.596
711	330597	no	Le Mont Mahury	Not Reported	1998	FRA	0.885
712	330599	no	Pointe Isere – Savane Sarcelle	Not Reported	1998	FRA	2.808
713	555562005	no	Savanes Et Marais De Macouria	Not Reported	2013	FRA	30.586
714	345932	no	Ilet Lavigne	Not Reported	2003	FRA	0.147
715	392042	no	Cul De Sac De Petite Grenade	Not Reported	2006	FRA	0.114
716	330640	no	Ilet Thierry	Not Reported	2005	FRA	0.113
717	391957	no	Ilet Chancel	Not Reported	2005	FRA	0.565
718	147300	no	Martinique	Not Applicable	1976	FRA	36.422
719	147321	no	Pointe Rouge	Not Reported	1985	FRA	0.258
720	555589803	no	Pointe De Massy-Massy	Not Reported	2015	FRA	0.440
721	555589801	no	Le Galion - Pointe Jean-Claude	Not Reported	2015	FRA	0.233
722	555597297	no	Martinique	Not Reported	2017	FRA	47433.614
723	391958	no	Pointe Jean Claude	Not Reported	2008	FRA	0.166
724	345928	no	Forêt Lacustre Du Galion	Not Reported	1999	FRA	0.127
725	345933	no	Ilet Long	Not Reported	2003	FRA	0.209
726	83290	no	Presqu'Île De La Caravelle	Not Reported	1976	FRA	1.377
727	555589628	no	Pointe Rouge - Morne Pavillon	Not Reported	2016	FRA	1.653
728	555597238	no	Baie De Sans Souci	Not Reported	2017	FRA	0.166

729	555597232	no	Marine Du Prêcheur - Albert Falco	Not Reported	2014	FRA	1.400
730	555597385	no	Périmètre De Protection De La Réserve Des Ilets De Sainte-Anne	Not Reported	1995	FRA	1.067
731	147320	no	Macabou	Not Reported	1982	FRA	1.268
732	555597237	no	Baie Du Simon	Not Reported	2017	FRA	0.155
733	555705254	no	Zona de Utilidad Pública y de Interés General, un inmueble ubicado en la Costa del Golfo de Venezuela, Estado Zulia	Not Reported	1974	VEN	175.937
734	10767	no	San Esteban	Not Applicable	1987	VEN	29.338
735	145555	no	Parque Nacional Archipiélago Los Roques	Not Reported	1996	VEN	2155.680
736	2245	yes	Archipiélago Los Roques	Not Reported	1972	VEN	2155.680
737	146676	no	Delta del Orinoco (Mariusa)	Not Applicable	1991	VEN	3.821
738	20085	no	Ciénagas de Juan Manuel, Aguas Blancas y Aguas Negras	Not Applicable	1975	VEN	11.316
739	14192	no	Limlair Theboud	Not Reported		GRD	0.207
740	555592967	no	Grand Bay	Not Reported		GRD	0.127
741	12705	yes	Levera	Not Reported		GRD	6.064
742	555592968	no	Sandy Island-Oyster Bay	Not Reported	2009	GRD	5.209
743	14189	no	Southern Seascape	Not Reported		GRD	83.700
744	14188	no	La Sagesse	Not Reported		GRD	0.123
745	555592974	no	Petite Dominique	Not Reported		GRD	1.699
746	555592980	no	Conference Bay	Not Reported		GRD	10.029
747	116321	yes	Mt. Hartman	Not Reported		GRD	0.215
748	555592983	no	Woburn-Clarks-Court Bay	Not Reported	1999	GRD	2.182
749	555592984	no	Ronde Island Group	Not Reported		GRD	63.970
750	555592987	no	South Carricou Islands	Not Reported		GRD	20.160
751	31448	no	Hog Island	Not Reported		GRD	0.262
752	555592990	no	Grand Anse	Not Reported	2018	GRD	17.624

753	555547958	no	Levera Wetland	Not Reported	2012	GRD	0.372
754	555697540	no	Gouyave	Not Reported		GRD	3.174
755	555705246	no	Utilidad Pública y de Interés Turístico Recreacional El Castillo de Araya	Not Reported	1974	VEN	0.743
756	30028	no	Delta del Orinoco	Not Applicable	1991	VEN	424.048
757	2247	yes	Morrocoy	Not Reported	1974	VEN	196.448
758	324	yes	Mochima	Not Reported	1973	VEN	475.598
759	10779	no	Imataca	Not Applicable	1961	VEN	16.393
760	2246	yes	Medanos de Coro	Not Reported	1974	VEN	413.075
761	328	no	Península de Paria	Not Applicable	1978	VEN	6.144
762	331	yes	Laguna de Tacarigua	Not Reported	1974	VEN	261.549
763	145558	no	Laguna de Tacarigua	Not Reported	1996	VEN	261.549
764	145557	no	Laguna de La Restinga	Not Reported	1996	VEN	66.609
765	68319	no	Refugio de Fauna Silvestre de Cuare	Not Reported	1988	VEN	21.279
766	145556	no	Refugio de Fauna silvestre y Reserva de Pesca Ciénaga de Los Olivitos	Not Reported	1996	VEN	61.836
767	10778	no	Litoral Central	Not Applicable	1974	VEN	3.152
768	340	no	Cuare	Not Reported	1972	VEN	21.279
769	31274	no	Ciénaga de Los Olivitos	Not Reported	1986	VEN	61.836
770	310	yes	Laguna de Las Marites	Not Reported	1974	VEN	9.453
771	308	yes	Las Tetas de María Guevara	Not Reported	1974	VEN	2.032
772	10786	no	Selva de Guarapiche	Not Applicable	1963	VEN	127.855
773	30023	no	Ciénagas de Juan Manuel	Not Reported	1991	VEN	227.863
774	30024	no	Turuépano	Not Applicable	1991	VEN	39.583
775	336	yes	Laguna de La Restinga	Not Reported	1974	VEN	66.609

776	101102	no	Río Guanipa	Not Applicable	1991	VEN	4.287
777	101087	no	Merejina	Not Applicable	1991	VEN	76.531
778	20088	no	Zona Sur Lago de Maracaibo	Not Applicable	1974	VEN	18.505
779	101165	no	Laguna Blanca o del Morro	Not Reported	1992	VEN	0.892
780	101174	no	Hueque - Sauca	Not Reported	2005	VEN	63.247
781	101133	no	Cuenca del Río Tuy	Not Applicable	1992	VEN	56.039
782	4365	no	Isla Aves	Not Reported	1972	VEN	1566.991
783	555705252	no	Utilidad Pública y de Interés Turístico Recreacional Orilla de Laguna Grande en la Península de Araya	Not Reported	1974	VEN	9.007
784	30646	no	Islas e Islotes, Laguna, Cabos y Puntas	Not Applicable	1988	VEN	1.302
785	555705253	no	Utilidad Pública y de Interés Turístico Recreacional Sectores Punta El Escarpado - Playa San Luis	Not Applicable	1974	VEN	1.740
786	555705231	no	Puerto América	Not Reported	1999	VEN	219.433
787	555705232	no	Ciénaga de la Palmita e Isla de Pájaros	Not Reported	2000	VEN	9.905
788	555705249	no	Utilidad Pública y de Interés Turístico Recreacional Playa La Tutush (Güiria)	Not Reported	1974	VEN	1.645
789	555705250	no	Porciones de Territorio Ccomprendidas entre los Centros Poblados de San Juan de los Cayos - Chichiriviche y El Cruce - Tucacas - Boca de Yaracuy	Not Applicable	1996	VEN	8.253
790	555705257	no	Zona de Interés Turístico, Sector El Yaque	Not Reported	1996	VEN	2.462
791	555705259	no	Zona de Utilidad Pública y de Interés Turístico Recreacional La Península de Paraguaná	Not Reported	1974	VEN	627.217

792	555705262	no	Utilidad Pública y de Interés Turístico Recreacional El Litoral de la Región Capital (Estado La Guaira - Estado Miranda)	Not Applicable	1974	VEN	4.638
793	555705264	no	Dependencias Federales: Isla La Tortuga, Las Tortuguillas, Cayo Herradura, los Palanquines, y su Espacio Acuático Asociado	Not Reported	1974	VEN	725.337
794	555705271	no	Playa Norte	Not Reported	2002	VEN	1.098
795	555705277	no	Isla Cubagua	Not Reported	1943	VEN	24.947
796	555555848	no	Musichi	Not Reported	2011	COL	3.902
797	555697787	no	Pastos Marinos Sawairu	Not Reported	2018	COL	656.100
798	555592746	yes	Bahia Portete Kaurrele	Not Reported	2014	COL	110.196
799	10565	no	Chassahowitzka National Wildlife Refuge	Not Reported	1943	USA	47.058
800	22990	no	Caladesi Island State Park	Not Reported	1966	USA	7.654
801	666672	no	Waccasassa Bay State Preserve	Not Reported	1971	USA	18.181
802	555655949	no	Chassahowitzka	Not Reported	1941	USA	47.058
803	666642	no	Crystal River Preserve State Park	Not Applicable	1974	USA	7.969
804	555658265	no	Waccasassa Bay	Not Reported		USA	18.890
805	555603421	no	Chassahowitzka National Wildlife Refuge	Not Reported	1977	USA	46.549
806	555585657	no	Anclote Key State Park	Not Reported	1960	USA	46.939
807	555586027	no	Honeymoon Island State Park	Not Reported	1974	USA	8.064
808	555586061	no	Werner-Boyce Salt Springs State Park	Not Reported	1992	USA	2.767
809	555586066	no	Cedar Key Scrub State Reserve	Not Applicable	1978	USA	1.702
810	555586755	no	St. Martins Marsh Aquatic Preserve	Not Reported	1969	USA	61.792
811	555658251	no	Anclote Key	Not Reported		USA	46.939
812	555658254	no	Crystal River	Not Applicable	1974	USA	7.257
813	555662473	no	Caladesi Island	Not Reported	1966	USA	7.398
814	555662560	no	Werner-Boyce Salt Springs	Not Reported	1992	USA	2.767

815	555662942	no	Cedar Key Scrub	Not Applicable	1978	USA	1.702
816	1069	no	Canaveral National Seashore	Not Reported	1975	USA	25.658
817	2880	no	Merritt Island National Wildlife Refuge	Not Reported	1963	USA	53.128
818	555583372	no	Thousand Islands	Not Reported		USA	0.500
819	555586765	no	Banana River Aquatic Preserve	Not Reported	1970	USA	93.587
820	666620	no	St. Marks National Wildlife Refuge	Not Applicable	1975	USA	4.712
821	2891	no	St. Marks National Wildlife Refuge	Not Applicable	1931	USA	7.042
822	555585509	no	John S. Phipps	Not Reported	1977	USA	0.170
823	555586744	no	Alligator Harbor Aquatic Preserve	Not Reported	1969	USA	55.229
824	555656142	no	St. Marks	Not Applicable	1931	USA	7.042
825	315001	yes	Walker's Cay National Park	Not Reported	2002	BHS	18.694
826	555625734	no	Northshore / The Gap National Park	Not Reported	2015	BHS	781.706
827	11840	yes	Peterson Cay National Park	Not Reported	1968	BHS	4.403
828	555592587	yes	Crab Cay Marine Reserve	All	2010	BHS	3.025
829	11841	yes	Lucayan National Park	Not Reported	1977	BHS	7.263
830	555625722	no	East Grand Bahama National Park	Not Reported	2015	BHS	411.111
831	10574	no	Pelican Island National Wildlife Refuge	Not Reported	1903	USA	14.704
832	555584897	no	Snook Islands	Not Reported		USA	0.387
833	29737	no	St. Lucie Inlet Preserve State Park	Not Reported	1965	USA	15.114
834	555586769	no	Indian River - Vero Beach to Ft. Pierce Aquatic Preserve	Not Reported	1969	USA	31.985
835	555586770	no	Jensen Beach to Jupiter Inlet Aquatic Preserve	Not Reported	1969	USA	78.350
836	555586019	no	Fort Pierce Inlet State Park	Not Reported	1963	USA	1.371
837	555586772	no	Loxahatchee River - Lake Worth Creek Aquatic Preserve	Not Reported	1970	USA	2.438
838	555586775	no	North Fork, St. Lucie Aquatic Preserve	Not Reported	1984	USA	6.014

839	555586817	no	Urca de Lima Underwater Archaeological Preserve	Not Reported	1987	USA	0.120
840	555586823	no	Lofthus Underwater Archaeological Preserve	Not Reported	2004	USA	0.363
841	555586826	no	Georges Valentine Underwater Archaeological Preserve	Not Reported	2006	USA	0.498
842	555658260	no	St. Lucie Inlet	Not Reported	1965	USA	15.106
843	103168	yes	Yum Balam	Not Reported	2008	MEX	935.475
844	555587175_B	yes	La porción norte y la franja costera oriental, terrestres y marinas de la Isla de Cozumel	Not Reported	2012	MEX	306.689
845	902294	no	Parque Nacional Arrecife de Puerto Morelos	Not Reported	2004	MEX	88.933
846	124383	yes	Belize Barrier Reef Reserve System	Not Reported	1996	BLZ	1079.326
847	312188	no	Tortugas Marine Reserves Habitat Areas of Particular Concern	Not Reported	2002	USA	230.028
848	555592585	yes	Westside National Park	Not Reported	2012	BHS	2136.796
849	13091	no	Apalachicola National Estuarine Research Reserve	Not Reported	1979	USA	423.067
850	14005	no	Saba	Part	1987	NLD	2686.886
851	555629451	no	Arrecifes del Suroeste	Not Reported	2009	DOM	2698.337
852	168260	no	Alejandro de Humboldt	Not Applicable	2001	CUB	24.744
853	555586751	no	Pinellas County Aquatic Preserve	Not Reported	1972	USA	1369.819
854	6666277	no	Guana Tolomato Matanzas National Estuarine Research Reserve	Not Reported	1999	USA	108.890
855	108090	yes	Tiburón Ballena	Not Reported	2009	MEX	1454.522
856	555624306_A	yes	Caribe Mexicano Profundo	Not Reported	2016	MEX	37992.911
857	555542783	no	Manglares y Humedales del Norte de Isla Cozumel	Not Reported	2009	MEX	254.690
858	555624226	no	Dry Tortugas	Part	1935	USA	296.277
859	555655850	no	Dry Tortugas	Not Reported	1992	USA	282.843

860	13444	no	Baitiquirí	Not Reported	2010	CUB	13.348
861	555625728	no	Marls of Abaco National Park	Not Reported	2015	BHS	544.027
862	555643706	no	Marine Management Area	Part	2016	KNA	405.921
863	317045	no	Cuchillas del Toa	Not Applicable	2010	CUB	63.510
864	666649	no	Fakahatchee Strand State Preserve	Not Applicable	1974	USA	1.025
865	555655801	no	Guana Tolomato Matanzas	Not Reported	1999	USA	109.315
866	342346	no	Laguna Madre y Delta del Río Bravo	Not Applicable	2005	MEX	1974.280
867	902311	no	Área de Protección de Flora y Fauna Yum Balam	Not Reported	2004	MEX	935.475
868	555583004	no	General Use Zone	Not Reported	2012	BLZ	990.159
869	122900	no	Florida Keys National Marine Sanctuary	Not Reported	1990	USA	9734.604
870	2228	yes	Exuma Cays Land & Sea Park	All	1958	BHS	567.759
871	555624205	no	Etangs des Salines	Not Applicable	1998	FRA	14.549
872	555703527	no	Yarari	None	2015	NLD	24877.181
873	555583148	no	Florida Coastal Islands Sanctuaries	Not Reported		USA	0.229
874	555625720	no	South Abaco Blue Holes National Park	Not Reported	2015	BHS	68.479
875	555655556	no	Big Bend Seagrasses Aquatic Preserve	Not Reported	1985	USA	2678.387
876	166966	yes	Arrecife de Puerto Morelos	Not Reported	1998	MEX	88.989
877	555624306_B	yes	Caribe Mexicano Profundo	Not Reported	2016	MEX	19313.982
878	555583002	no	Long Bouge Conservation Zone	Not Reported	2012	BLZ	3.019
879	555624227	no	Florida Keys	Part	1990	USA	9733.559
880	555625730	no	Cay Sal Marine Managed Area	Not Reported	2015	BHS	16715.130
881	302859	no	Boca de Cananova	Not Reported	2010	CUB	48.030
882	555655797	no	Apalachicola	Not Reported	1979	USA	420.471
883	555587040	no	Agoa	Not Reported	2010	FRA	142966.408

884	900628	no	Alejandro de Humboldt National Park	Not Applicable	2001	CUB	24.568
885	555705224	no	Lago de Maracaibo	Not Reported	1981	VEN	13186.081
886	555586768	no	Indian River - Malabar to Vero Beach Aquatic Preserve	Not Reported	1969	USA	95.792
887	166738	no	Sistema Delta Estuarino del Río Magdalena, Ciénaga Grande de Santa Marta	Not Applicable	1998	COL	554.375
888	903037	no	Reserva de Usos Múltiples Río Sarstún	Not Applicable	2007	GTM	13.541
889	555542763	no	Humedal de Importancia Internacional Damani-Guariviara	Not Applicable	2010	PAN	33.982
890	555558401	no	Sistema de Humedales Cuyamel-Omoa	Not Applicable	2013	HND	34.574
891	555558400	no	Sistema de Humedales de la Isla de Utila	Not Reported	2013	HND	127.238
892	67989	no	Barras de Cuero y Salado	Not Applicable	1993	HND	23.681
893	555558395	no	Parque Nacional Manglares del Bajo Yuna	Not Applicable	2013	DOM	192.842
894	13979	no	French, Bush and Seal Cays	Not Reported	1987	GBR	0.173
895	900707	no	Mankòté Mangrove	Not Reported	2002	LCA	0.492
896	900706	no	Savannes Bay	Not Reported	2002	LCA	0.205
897	902732	no	Buccoo Reef / Bon Accord Lagoon Complex	Not Reported	2005	TTO	10.493
898	902733	no	Caroni Swamp	Not Applicable	2005	TTO	16.707
899	902804	no	Graeme Hall Swamp	Not Reported	2005	BRB	0.270
900	134956	no	Pelican Island National Wildlife Refuge	Not Applicable	1993	USA	12.085