



# Measuring MPAs in Continental North America: How Well Protected Are the Ocean Estates of Canada, Mexico, and the USA?

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Marine protected areas (MPAs) are a well-established conservation strategy, employed around the world to protect important marine species and ecosystems and support the recovery of declining populations. The continental waters of North America contain remarkable biodiversity, but many species face increasing pressure from overexploitation, climate change, and other anthropogenic impacts. Canada, Mexico, and the USA have pledged to protect at least 10% of their marine and coastal waters by 2020 as signatories to the Convention on Biological Diversity, and have made efforts to establish MPAs. These MPAs vary widely in terms of levels of protection and designation processes; information that is not reflected in official statistics. To this end, we critically examined progress toward the CBD target for marine protection in continental North American waters to determine how well ocean ecosystems are protected by MPAs. We reviewed government data to determine whether MPAs met four criteria: legal designation, permanence, presence of an administrative structure, and a completed management plan. Sites that met all four criteria were categorized as “implemented.” Any sites that failed to meet one or more criterion were considered “incompletely implemented” and excluded from the analysis. We also calculated the amount of “fully-protected” MPAs in which all extractive uses are prohibited. We found that <1% of North America’s continental ocean is protected, and only 0.04% is fully-protected. Canada has the least area protected with just 0.11% in implemented MPAs, and 0.01% in fully-protected MPAs. Mexico and the USA have 1.62 and 1.29% in implemented MPAs, and 0.11 and 0.03% in fully-protected MPAs, respectively. Results show that many North American MPAs are incompletely implemented and therefore currently fail to provide adequate protection. The inclusion of such sites in official government statistics can inflate the perception of how much, and how well, the ocean is protected. We outline some of the major challenges to MPA establishment in each country and offer recommendations to increase the number and effectiveness of MPAs in North America.

**Keywords:** marine protected areas, MPAs, aichi target 11, North America, Canada, Mexico, USA

## INTRODUCTION

A healthy global ocean is critical to all life on Earth, yet overfishing, climate change, pollution, development and industrial use, vessel traffic, and noise pollution threaten the wellbeing of our ocean. These threats do not act in isolation but occur simultaneously, amplifying their respective consequences (Halpern et al., 2007, 2008). Subsequent declines in marine species and ecosystem health (Dulvy et al., 2003; Lotze et al., 2006; Worm et al., 2006), particularly apex predators and keystone species, are well documented globally (Pauly et al., 1998; Estes et al., 2011).

Marine Protected Areas (MPAs) are a tried and tested conservation strategy (Halpern, 2003; Lester et al., 2009; Sala et al., 2013). The IUCN defines a MPA as “a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values” (Day et al., 2012). Although there is an increasing body of literature on best practices for MPA design and management, there are currently no minimum protection standards for MPAs. Levels of protection can vary considerably from fully-protected “no-take” areas—also known as marine reserves—to partially-protected multiple-use areas, to “paper parks” with little or no regulation of activities. Partially protected areas have limited benefits; they may prevent further degradation of marine ecosystems but will not support recovery of populations (Lester and Halpern, 2008; Rife et al., 2013a). Numerous studies have demonstrated that the most effective MPAs (i.e., those that produce greater abundance, diversity and/or biomass) are fully-protected no-take areas, that are well-enforced, large, mature, and physically isolated (Halpern et al., 2009; Lester et al., 2009; Molloy et al., 2009; Stewart et al., 2009; Coleman et al., 2013; Edgar et al., 2014). To maximize their effectiveness, MPAs should be designed systematically and strategically according to clearly defined conservation objectives and design guidelines that are informed by the best available science (Pressey et al., 1993; Gaines et al., 2010b; Jessen et al., 2011; Devillers et al., 2014).

There is a growing concern that, in an effort to avoid stakeholder conflict and reduce short-term socioeconomic costs, many MPAs do not possess the characteristics listed above, and therefore are currently ineffective. Devillers et al. (2014) found a “strong global pattern” of MPAs established in remote areas with limited human activities. The authors found the result to be the establishment of “residual reserves” that fail to protect ecologically important habitats or species. The USA has made significant progress in recent years in establishing and expanding large no-take areas in its remote and overseas territories, but it is less clear how much progress has been made in USA continental waters.

In a recent assessment of how MPA management effects performance and biodiversity outcomes Gill et al. (2017) identified 9 management indicators to evaluate effective MPAs. These indicators included legal designation, clearly defined boundaries, appropriate regulations, implemented management plans and sufficient administrative capacity,

specifically staff, budget, and enforcement capacity. They found that administrative capacity (staffing and budget capacity) were the most strongly associated with successful conservation outcomes and that most MPAs failed to meet the thresholds for effective management as measured by these indicators. Horta e Costa et al. (2016) also evaluated regulations and management plans to evaluate MPA effectiveness and proposed a new MPA classification scheme based on permitted activities within the MPAs. The authors noted that many MPAs lack management plans, enforcement and monitoring, and allow extractive activities and suggest that this mismatch between the management objectives MPA and the management reality causes uncertainty in the evaluation and measurement of global MPAs. A 2011 assessment of MPAs in British Columbia, Canada found that of the 161 sites assessed, 160 allowed commercial fishing to continue despite the majority being listed as IUCN category Ia, Ib, or II, suggesting a high degree of protection (Robb et al., 2011). These results suggest that official MPA statistics recorded by each country may not accurately represent the level of protection afforded.

There are 196 parties to the United Nations Convention on Biological Diversity (UN CBD) that have made a commitment to achieve the Aichi Biodiversity Targets. Aichi Target 11 requires that “By 2020, at least... 10% of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures...” (Thomas et al., 2014). Aichi Biodiversity target 11 sets a clear goal for MPA establishment with a firm timeline, and is therefore an important motivator for political action. A number of other important international agreements also set marine conservation goals; these include the United Nations Framework Convention on Climate Change and the Durban Accord. At the 2016 IUCN World Conservation Congress in Hawai'i, representatives from 100 countries passed a resolution agreeing to work toward protecting 30% of their ocean territories by 2030 (World Parks Congress, 2014), which is in keeping with current scientific recommendations (Gaines et al., 2010b; O'Leary et al., 2016). Some conservation scientists have recommended that as much as 50% of the ocean be protected for effective biodiversity conservation (Mittermeier et al., 2003; Locke, 2015; O'Leary et al., 2016; Wilson, 2016).

Globally, 3% of the ocean (including the areas beyond national jurisdictions) is within MPAs and 1.6% is within fully-protected MPAs; coverage within the ocean estate of all countries is 5.27% (MPAtlas, 2016). While some nations including Australia, Chile, Mexico, Palau, and South Africa are close to or have exceeded 10% MPA coverage, many other nations have significant work to do over the next 3 years to meet Aichi Target 11. The rush to meet the targets on time raises the concern that ease of establishment will take precedence over quality of protection, and many ineffective sites that have poor conservation measures in place will be counted toward these targets. The past decade has seen growing recognition of the importance of the global establishment of effective MPAs; the percentage of ocean within fully-protected areas has increased from 0.1 to 1.6% in this

time (Lubchenco and Grorud-Colvert, 2015; MPAtlas, 2016). However, this progress is largely due to the establishment of very large and very remote MPAs such as, the U.S. Pacific Remote Islands Marine National Monument (Shugart-Schmidt et al., 2015).

North America has a very large and diverse ocean estate, ranging from tropical to Arctic ecosystems. Marine ecosystems and species are not confined by geopolitical boundaries and so action or inaction in one country has significant consequences for its neighbor(s). Protection of North America's marine ecosystems will require significant effort and collaboration across Canada, Mexico, and the USA. Fortunately, there is a sound basis for cooperation; the Commission on Environmental Cooperation (CEC) is a tri-national organization that aims to support collaboration between these three nations on issues relating to environmental protection, including the establishment of MPAs. However, the CEC does not have authority to create or manage MPAs, enforce legislation or international agreements. Canada, Mexico, and the USA are all signatories to the UN CBD and thus have committed to achieving Aichi Target 11, although the USA did not ratify the convention and so is not beholden to the targets and deadlines specified under Aichi Target 11. All three countries have taken steps to establish MPAs, and there is an ongoing effort to coordinate efforts around MPA establishment and management. However, each country has a unique political, jurisdictional, and geographical context.

Canada has the longest coastline in the world and the second largest ocean estate, at 5,746,694 km<sup>2</sup>. Canada does not have overseas territories and its ocean estate falls under a combination of overlapping and disputed indigenous, federal, and provincial jurisdiction. Indigenous peoples have constitutionally protected rights to access resources and full and informed consent must be provided for MPA establishment (see **Table 1**). Provincial governments claim jurisdictional authority over the seabed out to 12 nautical miles (nm) from the shore and in inshore waters. The federal government claims jurisdiction over both the water column and the seabed from 12 to the 200 nm boundary (DFO, 2016). Thus, provincial governments regulate oil and gas activities and tenures in inshore waters, whereas the federal government regulates shipping and fishing, and offshore oil and gas beyond 12 nm. Canada has a Federal Marine Protected Area strategy, published in 2005 which identifies three federal agencies and legislative tools to designate MPAs: Fisheries and Oceans Canada can designate MPAs under the *Oceans Act*; Parks Canada can establish National Marine Conservation Area Reserves (NMCARs) under the *NMCA act*; and Environment and Climate Change Canada can designate marine National Wildlife Areas under the *Canada Wildlife Act*. Commercial fishing and navigation remain under the jurisdiction of Fisheries and Oceans Canada and Transport Canada, respectively, even within an MPA, necessitating coordination with these agencies.

Mexico has the smallest ocean estate of the three nations, at 3,274,495 km<sup>2</sup>, which includes portions of the Pacific Ocean, Gulf of California, Gulf of Mexico, and Caribbean Sea. Like Canada, Mexico has no overseas territories. The federal government has exclusive jurisdiction over Mexico's marine waters, which has simplified the designation of MPAs but restricts the establishment

of MPAs to federal government action. Nonetheless, some state governments have already designated their own MPAs. The National Protected Areas Commission (CONANP) is the federal agency responsible for the designation and management of MPAs, however it does not have direct authority over fisheries, shipping, and mining within MPAs and requires engagement from other agencies. Oil and gas extraction is explicitly prohibited from all MPAs, which is not the case in Canada and the USA.

The USA has a continental ocean estate of 6,165,586 km<sup>2</sup>. The federal government claims jurisdiction over a territorial sea that extends to 12 nm from the shore and is responsible for managing all resources within the EEZ out to 200 nm. Coastal states have jurisdiction over state waters that extend 3 nm from the low-water mark, except for the states of Florida and Texas that claim state waters to 9 nm from the low water mark in the Gulf of Mexico. The USA also claims 14 overseas territories with adjacent territorial waters and EEZ, which were excluded from this analysis of continental North America. In federal waters the National Ocean and Atmospheric Administration (NOAA) establishes MPAs under the *National Marine Sanctuaries Act, 1972*. Additionally, the President has authority under the *Antiquities Act of 1906* to designate national monuments via executive order. As with Canada and Mexico, marine activities like fishing and shipping are typically managed by other federal and state agencies and so require coordination with other agencies.

In this analysis, we assess the progress of each country in establishing and implementing MPAs, and their collective efforts on a North American continental scale as well as provide recommendations for future MPA establishment.

## MATERIALS AND METHODS

We identified four key criteria for MPA designation, based on the IUCN definition (Day et al., 2012), examples from the scientific literature, and professional experience. These four criteria are: legal designation of MPA boundaries, designation in perpetuity or indefinitely, presence of administrative personnel and budget, and presence of a complete management plan and/or appropriate regulations. The first two criteria address the requirements under the IUCN definition that MPAs are clearly defined, dedicated and recognized. The latter two criteria are intended to address the requirement that MPAs are appropriately managed. According to the IUCN, effective MPAs should have an ongoing management planning process and written management plan that details management measures, desired outcomes, indicators of success, and monitoring plans (Pomeroy et al., 2004). In some jurisdictions, notably in Canada, MPA legislation does not state specific prohibitions, instead permitted and prohibited activities are detailed in the regulations and in the management plan. Thus, management plans may also be necessary to determine what activities are being managed within the MPA. Similarly, presence of an administrative structure indicates the ability to enforce regulations (Gill et al., 2017); without personnel and a budget, enforcement is impossible. These two criteria represent the

**TABLE 1** | Comparison of official national statistics of Canada, Mexico, and USA with implemented, incompletely implemented and fully-protected MPAs identified in this analysis.

Country	Total ocean estate (km <sup>2</sup> )	All MPAs counted in national statistics <sup>a</sup>			Implemented MPAs			Incompletely implemented MPAs			Fully-protected areas <sup>b</sup>		
		#	km <sup>2</sup>	%	#	km <sup>2</sup>	%	#	km <sup>2</sup>	%	#	km <sup>2</sup>	%
Canada	5,746,694	315	49,848	0.87	9	6,101	0.11	306	43,748	0.76	1 full 2 partial	477	0.01
Mexico	3,274,495	43	50,873	1.62	34	48,475	1.54	12	648,426	19.80	13 partial	3,439	0.11
USA	6,165,586 <sup>c</sup>	736	79,825	1.29	736	79,825	1.29	0	0	0	91	1,744	0.03
North America	15,186,775	1,094	180,546	1.19	779	134,401	0.88	318	692,174	4.55	92 full 15 Partial	6,221	0.04

Results are shown by number of individual MPAs, total marine area (km<sup>2</sup>) and percent of ocean estate.

<sup>a</sup>Official national statistics were taken from Environment Canada, CONANP, and NOAA.

<sup>b</sup>The number of fully-protected MPAs are shown as "full" where the entire MPA is fully-protected and "partial" where a portion of the MPA is fully-protected but the rest is multiple use. Fully-protected MPAs are a subset of implemented MPAs.

<sup>c</sup>The total USA ocean estate calculated here excludes Hawai'i and overseas territories.

minimum requirements for management and are not intended to provide a measure of MPA effectiveness, which is beyond the scope of this analysis.

Data on existing and proposed MPAs, including coordinates, were compiled from various sources including the United Nations Environment Program's World Conservation Monitoring Centre (UNEP-WCMC), MPAAtlas.org, Environment Canada, NOAA, and CONANP. Datasets were compiled into a single database for each country. Sites were evaluated to ensure that they met the key criteria for designation. Sites that met all four criteria were considered implemented, sites that lacked one or more of the criteria were considered partially-implemented.

Where a management plan or evidence of an administrative structure was not publicly available for a given site, it was requested from the governing agency. If this information was not provided, the site(s) was considered incompletely implemented. MPAs established by agencies which lack jurisdiction over marine activities such as, fishing and marine transportation—and where no additional permanent and legislated regulation of these activities has been established—were also classified as incompletely implemented and excluded from the analysis. Spatial regulations that apply only to fishery management were not considered MPAs as they do not meet the IUCN definition of an MPA or the four criteria identified in this study: they are not legislated, they lack permanence, and they lack jurisdiction over other activities like oil and gas exploration and extraction, and marine transportation.

Only MPAs located within the continental waters of North America were considered; those in overseas territories and Hawai'i were excluded from the analysis. In Mexico, estuarine areas were also excluded from this analysis as the Mexican CONANP does not include these sites in their evaluation of MPA coverage (Oceguera-Salazar et al., 2016).

All sites that met all four criteria and were considered implemented were analyzed for total marine area by clipping MPA boundaries using high resolution coastline data so that only marine area was evaluated, as several sites included both marine and terrestrial shoreline components. For the analysis we used unprojected coordinates in the WGS84 datum. Next, MPAs were merged to avoid calculating overlapping areas and

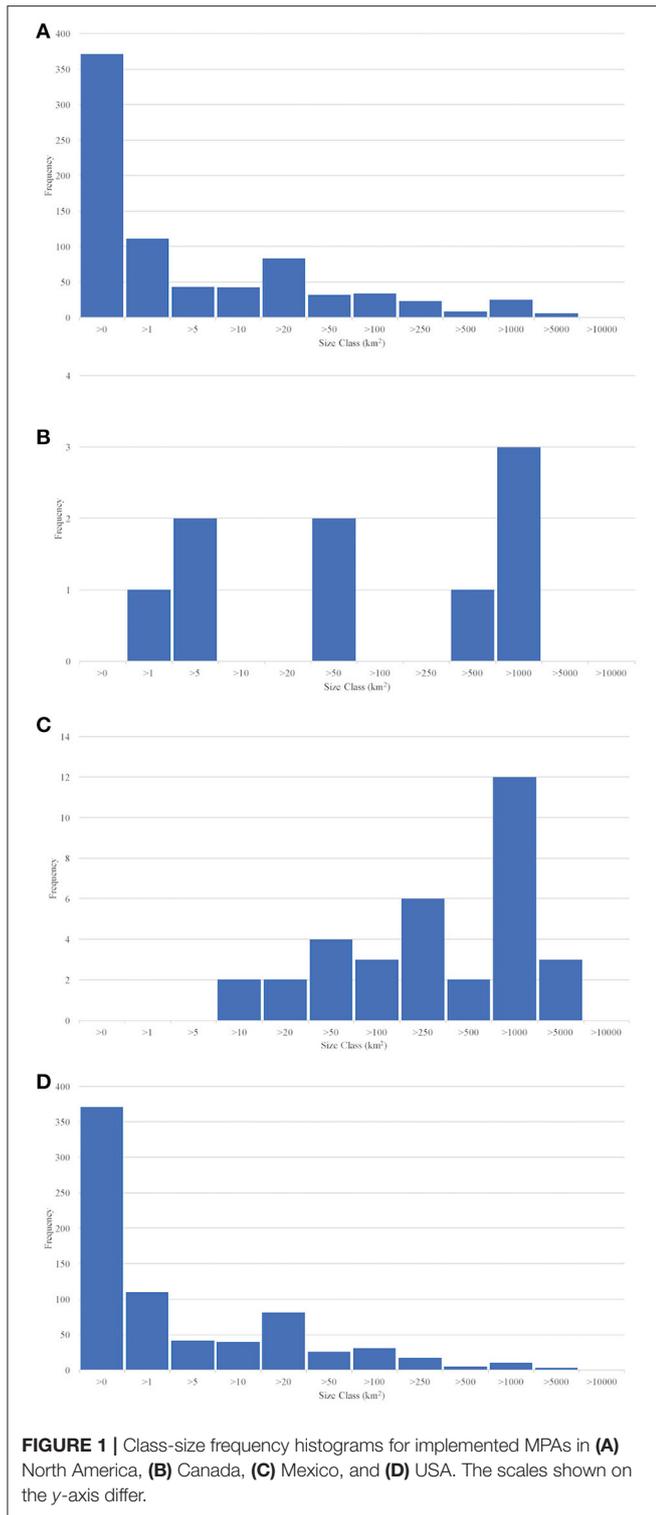
then area was calculated using geodetic area calculations in ArcGIS software. Total MPA area and fully-protected areas were calculated as a percentage of each country's marine estate (total waters from 0 to 200 nm from shore, inclusive of state, territorial, and exclusive economic zones) and combined for total coverage of North American continental waters. We used the Flanders Marine Institute EEZ boundary for this analysis (Flanders Marine Institute, 2014). Biogeographic coverage of implemented MPAs was also calculated using the CES's marine ecoregions (Wilkinson et al., 2009) to evaluate each country's progress to protect the full diversity of ecosystems and species. To assess representativity and evenness in the distribution MPAs across the ecoregions we used a modified version of the Gini coefficient. The Gini coefficient is a commonly used to quantify inequality by indicating the divergence from a perfectly equitable resource distribution, originally applied toward income inequality but equally suited for protected area coverage (Barr et al., 2011) The modified index as used by Barr et al. is bound between 100 (most even) and 0% (least even), making it easy to interpret.

## RESULTS

In total, we identified 779 implemented MPAs in North American continental waters covering 0.88% (134,401 km<sup>2</sup>) of North American continental waters (Table 1). Fully-protected MPAs cover 0.04% (6,221 km<sup>2</sup>) of North American continental waters. In addition, we identified 318 incompletely implemented MPAs in Canada and Mexico that covered an additional 4.55% (692,192 km<sup>2</sup>) of the combined North American continental ocean estate (Table 1). There is an overall tendency in North America toward small MPAs (Table 1, Figure 1A).

### Canada

In Canada, 9 sites met all four criteria and were classified as implemented MPAs covering 0.11% (6,101 km<sup>2</sup>) of Canada's ocean estate (Table 1). Of those, 1 site was fully-protected and 2 sites contained fully-protected zones within a multiple use MPA. Altogether 0.01% (477 km<sup>2</sup>) of Canada's ocean estate is fully-protected. There are 14 proposed MPAs in Canada that, if fully



**FIGURE 1 |** Class-size frequency histograms for implemented MPAs in (A) North America, (B) Canada, (C) Mexico, and (D) USA. The scales shown on the y-axis differ.

**TABLE 2 |** Summary statistics for the size of implemented MPAs in North America’s continental ocean estate, and by country.

	Area (km <sup>2</sup> ) <sup>a</sup>			
	North America	Canada	Mexico	USA
Mean	179.36	677.84	1,431.40	115.43
Median	1.21	97.07	531.98	0.92
Standard Deviation	957.63	876.51	1,832.49	855.53
Minimum	<0.01	2.98	11.10	<0.01
Maximum	15,770.77	2,363.93	6,208.49	15,770.77
Count	779	9	34	736

<sup>a</sup>All units in square kilometers except count which is shown as number of sites.

small to make inferences about trends in MPA size (Table 2, Figure 1B). On a regional level, of the 0.11% of Canada’s ocean estate that is protected, 0.03% is in the Arctic and 0.08% is in Atlantic Canada. The only MPA in Pacific Canada to meet the criteria for an implemented MPA is the Endeavor Hydrothermal Vents MPA, which, at <100 km<sup>2</sup> in size, contributes <0.01% of Canada’s national ocean estate. There are two other federally designated MPAs in Pacific Canada (Gwaii Haanas National Marine Conservation Area Reserve/Haida Heritage Site and SGaan Kinghlas/Bowie Seamount MPA) but these sites both lack final management plans and so were considered incompletely implemented in this analysis.

More than 300 sites were categorized as incompletely implemented because they did not meet the criteria for an implemented MPA, covering 0.76% (43,748 km<sup>2</sup>) of Canada’s ocean estate. More than two-thirds of these sites were excluded as the provincial governing agency lacked regulatory authority over marine activities such as, fishing and shipping and the sites lacked additional regulations or a management plan that directed or restricted these activities. Other incompletely implemented sites included National Parks with a marine component (12 sites), National Wildlife Areas (14), and Migratory Bird Sanctuaries (52), all of which lacked management plans and regulations for marine activities.

### Mexico

We identified 34 implemented MPAs that cover 1.54% (48,475 km<sup>2</sup>) of Mexico’s ocean estate (Table 1). Mexico has 13 MPAs that have fully-protected zones, covering 0.11% (3,439 km<sup>2</sup>) of its ocean estate. There are 2 proposed MPAs that would protect a further 7.05% of Mexico’s ocean estate, if implemented. There are 12 incompletely implemented sites. Of these, 8 sites were established by states and therefore lack jurisdiction over marine activities. One additional MPA was federally designated but excluded from this analysis (Bahía de Chamela Islands Sanctuary) due to an unclear jurisdictional status on the legal designation of its marine component. In December 2016, 3 large federal MPAs (Baja California Pacific Islands, Mexican Caribbean, and Deep Mexican Pacific biosphere reserves) were designated but for which management plans and regulations have not yet been completed and so are still considered incompletely implemented. When these sites are strengthened to meet all four criteria for

implemented, could increase the percentage of Canada’s ocean estate in MPAs by 2–3%.

Canada’s implemented MPAs range in size from 2.98 to 2363.98 km<sup>2</sup>, with three MPAs that are larger than 1,000 km<sup>2</sup>; however, with only 9 implemented MPAs, our data set is too

an implemented MPA, they will add 19.80% to Mexico's MPA coverage.

The smallest MPA in Mexican waters was 11.10 km<sup>2</sup>, but Mexico has 15 MPAs that are more than 1,000 km<sup>2</sup> in size, the largest being 6,208.49 km<sup>2</sup> (Table 2). As a result, a size-class frequency distribution is skewed toward larger sites (Figure 1C). Of the 3 newly created and still unimplemented Mexican biosphere reserves, 2 sites are very large Mexican Caribbean (57,255 km<sup>2</sup>) and the Deep Mexican Pacific (577,862 km<sup>2</sup>). Regionally, of the 1.62% of the Mexican ocean estate in implemented MPAs, 0.66% is in the Pacific, 0.46% in the Gulf of California, 0.33% is in the Gulf of Mexico and 0.17% is in the Caribbean Sea.

### United States of America

The USA has 736 implemented MPAs covering 1.29% (79,825 km<sup>2</sup>) of its continental ocean estate, with an average size of 108 km<sup>2</sup> (Table 1). There are 91 fully-protected MPAs, totalling 0.03% (1,744 km<sup>2</sup>) of USA continental waters. If MPAs in overseas territories were included in this analysis MPA coverage in the USA would increase significantly to 16.32%, with 13.74% in fully-protected no-take zones (Shugart-Schmidt et al., 2015). We did not identify any incompletely implemented MPAs in USA waters.

The largest MPA in USA continental waters is the Monterey Bay National Marine Sanctuary at 15,770 km<sup>2</sup> (Table 2). In addition to this there are another 13 MPAs that are larger than 1,000 km<sup>2</sup>. However, the majority of MPAs are <1 km<sup>2</sup> (Figure 1D). Of the 1.29% of USA's continental ocean estate that

is protected, 0.73% is in the Pacific and 0.57% is in the Atlantic and Gulf of Mexico. California, Oregon, and Florida State waters are the most effectively protected of the continental USA in terms of MPA coverage, while 15 of the 22 coastal states that comprise the continental USA have no fully protected MPAs in their state waters.

### Ecoregions

Of the 23 ecoregions identified within North American continental waters, 18 contain an implemented MPA, or portion thereof (Figure 2). However, MPA coverage in the ecoregions was uniformly low. Only 3 ecoregions (South Florida/Bahamian Atlantic, Gulf of California, and Montereyan Pacific Transition) have more than 5% in implemented MPAs and only 5 ecoregions have more than 0.10% fully-protected. The Gulf of California is the most strongly protected ecoregion with 0.34% in fully-protected MPAs. We calculated the Gini coefficient based on the MPA and no-take marine reserve area coverage of both the top-level ecoregions within each country's marine estate (country distribution) as well as the level II geomorphological regions within each top level ecoregion (ecoregion distribution). All three countries had a relatively low score, both separately and combined. Where a score of 100% suggests perfect representativity and evenness across the ecoregions, Canada and the USA scored 28.14 and 28.15%, respectively, Mexico scored slightly higher at 35.08%. North America has a combined Gini coefficient of 26.21%, which was lower than the individual countries due to the overrepresentation of southern ecoregions at a national scale.

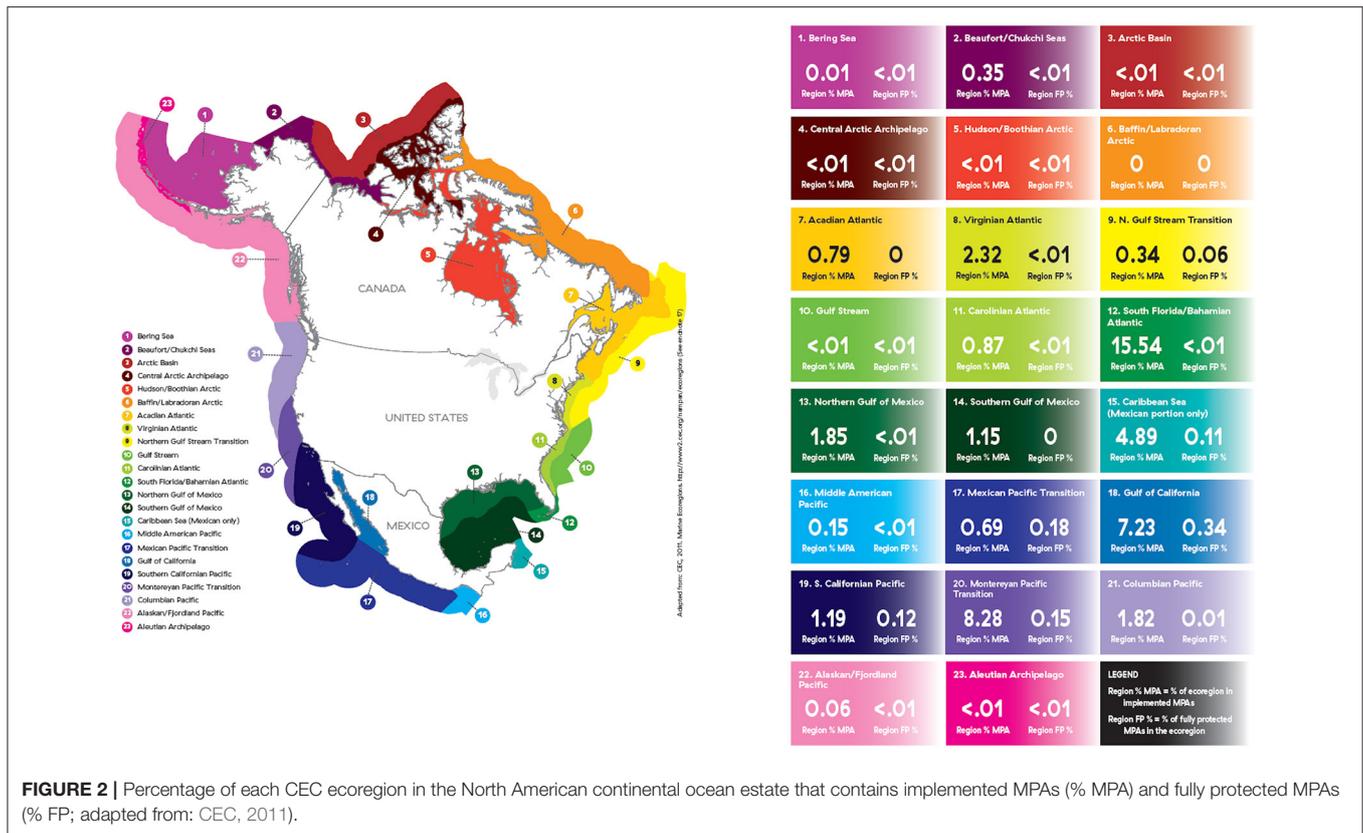


FIGURE 2 | Percentage of each CEC ecoregion in the North American continental ocean estate that contains implemented MPAs (% MPA) and fully protected MPAs (% FP; adapted from: CEC, 2011).

## DISCUSSION

Despite having the smallest ocean estate—and considering only currently implemented MPAs, Mexico has protected substantially more of its ocean (1.54%) than Canada (0.11%) and the USA (1.29%, excluding the large central Pacific MPAs in the USA). Mexico also has significantly more of its ocean in fully-protected MPAs (0.11%) than either the USA (0.03%) or Canada (0.01%). Of the three countries, Canada has the lowest percentage of its ocean estate protected in both implemented MPAs and fully-protected areas. The median size of Mexican MPAs is significantly larger than Canada or the USA (Table 2), although the sheer number of individual MPAs in USA waters offsets this size difference in terms of total coverage (Figure 1). The USA has many fully-protected MPAs that are small (<20 km<sup>2</sup>).

Altogether, <1% of North American continental ocean falls within implemented MPAs and only 0.04% is within fully-protected areas. Of the three countries, Canada is furthest from achieving its targets. In 2015, the government of Canada reaffirmed its intention to meet Aichi target 11, however currently proposed sites would only add 2–3% to Canada's national MPA coverage. In contrast, Mexico recently designated 3 new MPAs (currently incompletely implemented due to the lack of management plans and regulations) totalling nearly 20% of the Mexican ocean estate and has a further 2 proposed MPAs, that when designated will add another 7.05% to Mexico's MPA coverage. This will place Mexico well past the Aichi target 11 and closer to the 30% target recently set at the 2016 World Parks Congress (World Parks Congress, 2014). If MPAs in overseas territories and remote areas are included, the USA has already exceeded the Aichi target 11. However, it is clear from this analysis and others (e.g., Shugart-Schmidt et al., 2015) that USA continental waters remain largely unprotected. A significant increase in the total area of continental waters protected through networks of effective MPAs is needed, as these are the most heavily exploited and seriously impacted marine ecosystems (Halpern et al., 2007, 2008).

The USA did not ratify the UN Convention on Biological Diversity and so is not beholden to the targets and deadlines set out under Aichi Target 11. However, Canada and Mexico are signatories and have made a commitment to protect 10% of their ocean estate by 2020. The race to meet this deadline poses interesting questions about what should and should not be included in each country's MPA statistics. The IUCN provide a clear definition of an MPA, however there is some flexibility and room for interpretation in the definition of how a site is “managed.” As there are no internationally agreed upon minimum standards there is some room for interpretation as to what meets the definition of a site that is “... recognized, dedicated, and managed, through legal or other effective means to achieve the long-term conservation of nature...” In this analysis, we have attempted to define criteria, based on the IUCN definition, to determine which sites can be considered implemented MPAs that can be counted toward Aichi target 11. We used the presence of an administrative structure and the creation of a management plan as proxy criteria for “management” however we recognize that the presence of a

management plan or administrative structure does not guarantee effectiveness, and there may be some instances where sites lack management plans and administrative structures but have a high-level of compliance and community buy-in and so are effective MPAs.

Furthermore, while the IUCN have developed “management categories” representing a range of conservation objectives and protection levels to support the accounting of protected areas there are no targets for each category (Day et al., 2012). The categories range from category Ia “strictly protected areas” that should prohibit any extractive uses, to category VI that allows for “sustainable use” and in some cases, may permit activities like mining (Day et al., 2012). So theoretically, a country could meet Aichi Target 11 while allowing mining throughout all its MPAs. More recently, at the 2016 World Conservation Congress the IUCN passed Motion 26 which recommends that states should “prohibit environmentally damaging industrial activities and infrastructure development in all IUCN categories of protected area” (IUCN, 2016). However, these recommendations are not legal requirements and the inconsistency with the definitions of the management categories leaves some room for interpretation.

Here we have reported the total area of implemented MPAs that are in fully protected no-take areas, however this is not a requirement for nations in their national MPA statistics. The IUCN management categories attached to each site are intended to give an indication of the relative proportions of strongly and less-strongly protected MPAs, however our analysis supports previous studies that have identified a mismatch between the reported IUCN categories and the reality of protection standards in MPAs (Robb et al., 2011; Horta e Costa et al., 2016).

Throughout our analysis we identified similar challenges and opportunities to establishing effective MPA networks and meeting the 10%, and more recent 30% MPA targets across the three nations; we offer the following recommendations for MPA policy, planning, and establishment to ensure effective and comprehensive marine conservation.

### Designate and Fully Implement Proposed MPAs, Including Strengthening Incompletely Implemented Sites

There are more than 300 incompletely implemented sites and several proposed MPAs in Canada and Mexico. Most of these sites have been identified because of their ecological importance or cultural values or because they are threatened by human activities, and therefore they are in need of effective marine conservation measures. In the case of partially protected areas, much of the work will have already been done to identify ecological values and impacts from human activities and to consult, or at least inform, stakeholders. There is also some form of legislative or regulatory framework in place for partially protected sites, which could be used as a basis for additional regulations to ensure each site has meaningful protection. It should therefore require less effort and investment to strengthen protection measures and “upgrade” these sites to implemented MPAs. To further expedite this process, multiple incompletely

implemented areas could be upgraded simultaneously as a suite of sites through MPA network planning processes.

## Fully Protect Areas

Current scientific recommendations are to fully protect at least 30% of marine habitats to maximize the benefits of MPAs (Gaines et al., 2010b; Jessen et al., 2011; Shugart-Schmidt et al., 2015). O'Leary et al. (2016) recommend that to achieve effective ocean conservation we need to designate at least 30% of the ocean in highly protected MPAs, which is consistent with the recommendations from the 2016 World Parks Congress (IUCN, 2017). Scientific studies conclusively demonstrate that fully-protected areas are far more effective than partially-protected areas, producing greater benefits in terms of biodiversity conservation and productivity (Lester and Halpern, 2008; Wilson et al., 2013; Costello, 2014; Edgar et al., 2014). However, per our analysis, just 0.04% of North America's ocean estate is fully-protected. We found that <0.01% of Canadian waters are in fully protected areas and 0.76% are in MPAs that are not fully implemented. This is consistent with previous analyses of Canadian MPAs and MPA legislation which have found standards of protection are generally low, restrictions on commercial fishing and industrial activities are rare, and exemptions from existing prohibitions are common (Robb et al., 2011; CPAWS, 2015). Poorly protected MPAs can inflate national statistics and give a misleading impression of the state of conservation (Agardy et al., 2011). In contrast, Mexico has recently taken steps to increase the standards of protection by prohibiting oil and gas extraction from all MPAs.

Strong compliance and enforcement is also critical to how well protected, and ultimately how effective, a MPA is (Guidetti et al., 2008; Rife et al., 2013b; Edgar et al., 2014). Here we used presence of a management plan and administrative structure as criteria to evaluate whether an MPA was implemented or not as these two factors represent the "bare essentials" required for enforcement. The large number of sites that were categorized as only incompletely implemented, largely because they lacked management plans and/or an administrative structure is therefore a concern in terms of the effectiveness of North America's MPAs. However, we acknowledge that the presence of these criteria does not guarantee enforcement and do not measure effectiveness. Compliance and enforcement are difficult to measure and need to be examined on a site by site basis, and so were not evaluated in this analysis. Acknowledging the challenges, we recommend that national-scale analyses of MPA compliance and enforcement are conducted as this will be critical in determining the effectiveness of the MPAs that have been designated.

## Create Large MPAs

Mexico's 3 recently designated and incompletely implemented MPAs are relatively large and in addition to 2 additional proposed MPAs, will together protect 27% of Mexico's ocean estate. By way of contrast, Canada's 14 proposed MPAs will protect an additional 2–3% of its ocean estate, though the federal government has identified the establishment of large MPAs in "pristine offshore areas" as part of its plan to meet the marine conservation targets

(Government of Canada, 2016a). Establishing large MPAs is therefore one strategy for meeting spatial marine conservation targets more efficiently. Evidence shows that large MPAs have benefits: they better protect species with larger ranges, can encompass a range of ecosystems and habitats to ensure connectivity, and provide a larger buffer against anthropogenic impacts for sensitive species and ecosystems (Gaines et al., 2010a; Agardy et al., 2011; Costello, 2014; Dudley et al., 2014; Edgar et al., 2014). However, although protecting very large and remote, near-pristine areas of ocean will have undoubtable benefit, there is a concern that large offshore MPAs are being designated in the rush to the 10% target at the expense of coastal waters, to avoid stakeholder conflict (Devillers et al., 2014; Shugart-Schmidt et al., 2015). There are also concerns about the enforceability and social equity of large offshore MPAs, especially when established in remote or overseas territories (De Santo, 2013). Therefore, it is important that large MPAs are designed around key features or biodiversity hotspots and are strongly protected.

## Establish Interim Protections

From identification as a candidate MPA through to final designation, the process to establish an MPA can take years, even decades. Several proposed MPAs in Canada have been under consideration and development for over 20 years (CPAWS, 2015). During that time, there are no protection measures in place and so the ecosystems and marine species remain at risk. To prevent further declines in biodiversity or ecosystem health while an MPA waits for designation, strict interim protection measures should be established to prohibit all potentially harmful activities until it can be determined that they do not impact the ecosystem in question and are consistent with the conservation objectives for the area (Kelleher, 1999; Jessen et al., 2011).

## Provide Consistent and Appropriate Funding

Adequate and consistent funding is critical to the successful design, establishment and management of MPAs and MPA networks (Guénette and Alder, 2007; Fox et al., 2013). Proper funding is needed to provide necessary logistical capacity and human resources, to ensure that the process is informed by the best available science, and to promote stakeholder engagement, which fosters buy-in and compliance. In addition to adequate funding for establishment, continued funding to support management and enforcement is critical to ensure the effectiveness of MPAs (Guidetti et al., 2008; Rife et al., 2013b).

Lack of sufficient funding is the most pervasive threat to MPAs in Mexico. In Canada, the 2016 budget included an allocation of CA\$81.3 million in new funds over the next 5 years, to support marine conservation work by Fisheries and Oceans Canada and Natural Resources Canada, which includes MPA establishment and management (Government of Canada, 2016b). Environment and Climate Change Canada and Parks Canada also received funding to support MPA work, albeit more limited. An unpublished review of the 2015 USA budget by the Marine Conservation Institute found that NOAA's National Marine Sanctuaries program receives an annual budget of just over US\$50 million, with additional funding for other

marine conservation activities, some of which also supports MPA management. The Department of the Interior provides an additional US\$15 million in funding for MPAs to support its work managing several National Marine Monuments as well as National Parks and Wildlife Refuges that have a marine component. MPAs in state waters receive their own separate funding, creating a complicated web of funding arrangements that makes it challenging to estimate a single total figure.

Governments should be the main source of funding for MPAs, but other financial alternatives such as, public-private partnerships and philanthropic organizations can provide financial support for MPA establishment and management (Lubchenco and Grorud-Colvert, 2015). The California MPA network planning process was funded through a public-private funding partnership, and the significant and consistent injection of funding that this partnership provided has been highlighted as a key reason for the ultimate success of this process (Fox et al., 2013; Gleason et al., 2013). A similar approach has been taken for marine spatial planning (MSP) in British Columbia, Canada.

### Develop Network Planning

Like establishing large MPAs, network planning may be a more efficient and effective approach to establishing MPAs and meeting spatial marine conservation targets as several sites can be designed, evaluated and established simultaneously, rather than sequentially, with additional benefits. The IUCN defines an MPA network as "... a collection of individual MPAs or reserves 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." (IUCN WCPA, 2008). The intent behind MPA network planning is to scale up the benefits of MPAs by using a science-based approach and incorporating connectivity, representativity, and replication of ecosystems, and the maximization of fisheries benefits (Costello et al., 2010; Gaines et al., 2010a,b; Hamilton et al., 2010; Jessen et al., 2011; De Santo, 2013; Fox et al., 2013). MPA network planning can also provide multiple design and placement options, and a range of protection levels that can help to reduce stakeholder conflict (IUCN WCPA, 2008). In addition to these positive outcomes, developing a comprehensive network of MPAs can also be more efficient in terms of time and money than the existing site-by-site approach, by systematically assessing and designating a suite of sites simultaneously (Horigue et al., 2015; Lubchenco and Grorud-Colvert, 2015). MPA network planning has been successfully undertaken in the State of California (Gleason et al., 2013), Australia through the Great Barrier Reef rezoning (Day, 2008), Mexico's deep sea habitats (Bezaury-Creel et al., 2011), and is currently underway—at various stages—in several sites across Canada.

### Prioritize Effective Coordination and Reduce Jurisdictional Complexity

Throughout our analysis we found jurisdictional complexity to be an ongoing challenge in each country. All three countries have a complex and unique governance structure, and governance seems to be particularly complicated in the marine environment. In Canada and the USA, MPAs may be designated by multiple

agencies using multiple legislative tools, each of which has its own powers and limitations. In all three countries MPA legislation does not include the authority to manage marine activities like fishing and navigation, and additional regulations and management measures are required. However, management measures not written into legislation lack permanence and can be easily overturned. This complexity and opacity creates stakeholder uncertainty, which reduces buy-in and leads to unnecessarily long and expensive planning processes and a lack of clarity about how MPAs should be measured with respect to MPA targets (Jamieson and Levings, 2001; McCrea-Strub et al., 2011).

A strong mandate, effective enabling legislation, and political will are all critical to successful MPA planning and management (Fernandes et al., 2005; IUCN WCPA, 2008; Fox et al., 2013; Kirlin et al., 2013). Canada, Mexico, and the USA must overcome the jurisdictional complexity that currently impedes effective marine conservation within their respective borders. This could be achieved by increasing the regulatory powers of MPA legislation to manage marine activities and improving coordination across the various departments and levels of government within each nation (Guénette and Alder, 2007; Singleton, 2009).

### Establish Transboundary MPAs

There are currently no transboundary MPAs in North America. Transboundary MPAs have the potential to expand protective measures to an appropriate geographic scale for species and ecosystems, provide consistency in regulations to support compliance, and to create political stability in areas where there are disputes over borders or resource management. Transboundary protected areas are becoming increasingly common with the development of legislative tools and designations, like International Peace Parks and the Barcelona Convention (Charles and Sanders, 2006; IUCN WCPA, 2008; Dudley et al., 2014). Here we used the CEC ecoregions to analyze MPA coverage at a biogeographic scale. Although bioregional MPA network planning is underway in some regions of Canada, to the best of our knowledge, the CEC ecoregions are not being used as a framework for national or transboundary MPA network planning.

Transboundary MPAs could provide significant benefits for all maritime borders in North American, but in particular, the Arctic is a prime candidate for a transboundary MPA. Arctic marine species and ecosystems are particularly vulnerable to climate change and receding ice, and also face increasing industrial and commercial exploitation as previously inaccessible areas "open up" (Christiansen et al., 2014). New, or increasing, access to resources creates the potential for international disputes over resources and boundaries (Berkman and Young, 2009). We propose that large, transboundary MPAs have the potential to provide strong protection for species and ecosystems, ensure consistent management measures across boundaries, and resolve resource disputes by making contested areas "off limits" to all parties, thereby supporting political stability. The 2016 United States-Canada Joint Arctic Leaders Statement (Government of Canada, 2016c) was an important first step toward transboundary

collaboration in the Arctic, however it is unclear how the change in the USA presidential administration will affect this agreement.

## Build Consensus on MPAs and Implement Marine Spatial Planning

There is still strong opposition to MPAs despite the growing evidence that demonstrates significant benefits MPAs provide to coastal communities, including increasing the sustainability of fisheries, supporting the tourism and recreation, and ensuring ecosystem services from wave protection to carbon storage (Angulo-Valdes and Hatcher, 2010; Gaines et al., 2010a,b; Fox et al., 2012; Costello, 2014). Fully engaging stakeholders in the planning process will increase, though not guarantee, stakeholder buy-in and compliance (Guénette and Alder, 2007; Gleason et al., 2013; Lubchenco and Grorud-Colvert, 2015). MSP is a relatively new approach to marine resource management that brings together multiple stakeholders and marine users to develop zoning plans and management guidelines for the use of ocean resources. As a multi-stakeholder collaborative planning exercise, MSP has the potential to reduce user conflicts, overcome jurisdictional complexities, and address cumulative impacts (Crowder and Norse, 2008). MPAs are a key component of marine spatial plans; like MPA network planning, MSP allows may allow for the short-term costs of MPAs to be mitigated, and the long-term benefits enhanced, through the configuration of spatial zoning (Agardy et al., 2011; De Santo, 2013). However, we acknowledge that as a multi-stakeholder process that aims to balance the needs of multiple resource users, MSP does not necessarily prioritize conservation and does not guarantee positive outcomes for biodiversity conservation. Marine spatial plans were recently developed for the north coast of British Columbia, Canada, in a process that was co-led by the provincial government and First Nations. One output of the process was the identification of protection management zones that are now being considered in a trilateral federal-provincial-First Nations led MPA network planning process. As a comprehensive, multi-stakeholder planning process, MSP requires significant investment of time, funding, and logistical capacity; however, if done properly it has the potential to reap ecological, political,

social, and economic benefits (Crowder and Norse, 2008; Agardy et al., 2011).

In conclusion, our analysis found that <1% of continental North America's ocean estate is protected within implemented MPAs. Furthermore, despite scientific recommendations that 30% of marine habitats need to be strongly protected, just 0.04% of the North American ocean estate is in fully-protected no-take MPAs. We found that a large number of North American MPAs were only incompletely implemented and may therefore be inflating official MPA statistics providing a misleading sense of how well protected North American continental waters are. Canada has the least area protected, with 0.11% in implemented MPAs. Mexico has protected 1.54% of its ocean estate in implemented MPAs, and the USA has protected 1.29% of its continental waters in implemented MPAs. Of the 23 ecoregions that make up continental North America's ocean estate, 18 contained a protected area or portion thereof, but coverage was uniformly low across the ecoregions, with only three ecoregions having more than 5% protected in implemented MPAs. We identified several similar challenges and opportunities to MPA establishment in each country, and, based on our analysis, we offer a number of recommendations for more efficient and effective MPA establishment in North America.

## AUTHOR CONTRIBUTIONS

SJ and LM led the conception and design of the work. SJ, LM, JB, AB, RG, EP, and RM were involved in the acquisition, analysis and interpretation of data. SJ, LM, JB, AB, RG, and VS drafted the work. SJ, LM, JB, AB, RG, EP, VS, and RM provided review and revisions and final approval of the work.

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**Conflict of Interest Statement:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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