

## **Regional marine spatial planning measures to improve the Sustainability of the Seaflower MPA on the Colombian Caribbean Sea**

### *Medidas regionales de planeamiento espacial marino para mejorar la sostenibilidad del Área Marina Protegida de Seaflower en el mar Caribe colombiano*

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#### **ABSTRACT**

Studies in the Greater Caribbean regarding international maritime shipping traffic show an increase to at least double that of today. This threatens the ecosystems in the area due to the expansion of the Panama Canal and the possible Nicaragua Canal; the Marine Protected Area (MPA) Seaflower, in the Colombian insular Caribbean, is being affected by this increase. The present critical bibliographic review seeks to describe and analyze the problems that the MPA is facing today as a result of maritime traffic, such as wake waves and underwater noise, with the purpose of proposing and recommending some management and governance measures, based on the approach of Ecosystems Based Management (EBM). The objective is to analyze how to deal with the problems related to maritime industry, based on the protection measures established by the World Maritime Organization (IMO) to safeguard navigation security and ensure the sustainability of ecosystems in the long term.

**KEYWORDS:** MPAs, EBM, Colombia, The Seaflower MPA, maritime traffic, Wave wake, Underwater noise, ocean governance, PSSAs, sustainable development.

#### **RESUMEN**

*Estudios en el Gran Caribe respecto al tráfico marítimo internacional de buques muestra un incremento en al menos el doble del existente hoy. Esto amenaza los ecosistemas en el área debido a la expansión del Canal de Panamá y el posible Canal de Nicaragua; el Área Marina Protegida (AMP) Seaflower, en el Caribe insular colombiano, está siendo afectada por este incremento. La presente revisión bibliográfica crítica, busca describir y analizar los problemas que el AMP está enfrentando hoy producto del tráfico marítimo tales como el oleaje de estela y el ruido submarino con el propósito de proponer y recomendar algunas medidas de gestión y gobernanza, a partir del enfoque de Gestión Basado en los Ecosistemas (EBM siglas en Inglés). El objetivo es analizar cómo afrontar los problemas relacionados con la industria marítima, basados en las medidas de protección establecidas por la Organización Marítima Mundial (OMI) para salvaguardar la seguridad en la navegación y garantizando la sostenibilidad de los ecosistemas en el largo tiempo.*

**PALABRAS CLAVES:** AMP, EBM, AMP Seaflower, tráfico marítimo, oleaje de estela, ruido submarino, gobernanza de los océanos, PSSAs, desarrollo sostenible.

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## INTRODUCTION

Coasts and sea beds contain 80% of the biospheres of the earth, forming rich and diverse environments of fauna and flora, which in turn constitute key reserves for life (Plata G., 2009). These are being threatened by anthropogenic activities such as the increase in maritime traffic, which is causing problems with invasive species, marine pollution, and adverse effects due to the wake waves produced by traffic in specific areas, as well as the underwater noise produced by the cavitation of the propellers (Patrick and Storm, 2013). As a consequence, marine environments are suffering rapid degradation, generating an imbalance in the surrounding habitats (Van Tatenhove, 2013). To mitigate these impacts, the concept of Marine Protected Areas (MPA) has emerged, which has only gradually evolved from theory to practice (Jones, 2014). Therefore, today only 2.3 % of the world's oceans are protected by MPA (IUCN, UNEP-WCMC, 2013).

Part of these causes focus on weaknesses in governance at the local level (Taylor, Baine, Killmer & Howard, 2013) and weaknesses in the implementation of regional agreements and cooperation mechanisms with neighboring countries.

Colombia is the fifth largest and most biodiverse country in Latin America (Toro, Requena & Zamorano, 2009, "US Commerce Office", 2011, OECD, 2014, Alonso, and others, 2015), and due to its strategic position, it has jurisdiction in both oceans, the Caribbean and Pacific, corresponding to approximately 45 % of its national territory (Minambiente, 2012). The Caribbean coast has the largest extension with 600 000 km<sup>2</sup> of ocean (CCO, 2014; "Colombian Chancellery", 2016). The Seaflower Biosphere Reserve, located in the western Colombian Caribbean, contains the largest MPA in Colombia and one of the largest in the Greater Caribbean. This area faces problems which are causing the degradation of ecosystems, as a consequence of the increase in maritime traffic due to the extension of the Panama Canal. This will be exacerbated by the possible Nicaragua Canal.

Weaknesses in governance at local level (Taylor, Baine, Killmer & Howard, 2013) and

weaknesses in the implementation of regional agreements and cooperation mechanisms with neighboring countries are part of these causes. Therefore, it is necessary to implement local-level governance strategies with effective regional impact for the protection of key islands and coral reefs in the region.

This article seeks to define the regional measures of marine planning to improve the sustainability of the Seaflower MPA in the Colombian Caribbean Sea, considering the Ecosystem Based Approach (EBM). For this reason the EBM concept will be described, and the international and regional legal framework related to the governance of MPAs. The regulations established by the IMO for the protection of ecosystems from impacts caused by maritime traffic will also be briefly described. Different case studies of some areas in the world will be analyzed, considering their best practices in matters of marine spatial planning proposed by the IMO. Finally, it will be concluded by proposing and recommending which of these actions can be adopted in Colombia in order to improve governance within the Seaflower MPA.

### Governance in MPAs

Van Tatenhove (2013) defines ocean governance as the rules for collective decision making where multiple actors are involved and where there is no formal control system that dictates the relationships between them. It is important to define some concepts for its management and management such as the EBM approach and Marine Spatial Planning (MSP), precisely when governance is discussed in MPAs (Fanning, *et al.*, 2007, Lausche, 2011, UNEP, 2014a).

### Ecosystems Based Management (EBM)

According to UNEP (2014a), Long, Charles & Stephenson (2015), this approach was defined since the mid-70s as the conceptual framework that incorporates human activities at sustainable levels as an acceptable element within the functioning of ecosystems. It was recognized in the early 1980s when it was implemented in the Convemar as a concept for the foundation of this legal framework. Since then it has contributed to the structuring of marine policies worldwide.

Four fundamental principles comprise this approach, which seek the achievement of ecological objectives through the conservation of biological resources, mainly those in greater risk. In addition, this approach also recognizes social and governance objectives as part of its sustainable application. This concept maintains a close relationship with the concept of Marine Spatial Planning (MSP).

### **Marine Spatial Planning (MSP)**

MSP is defined as the "public process of analysis and location of human activities in a spatial and temporal way to achieve ecological, economic and social objectives that are usually specified through a political process" (Ehler, 2014). Therefore, they seek the protection and conservation of ecosystems through the sustainable use of marine and coastal resources. The MSP emerges as a solution to address all the activities carried out along coasts and in oceans, and like the EBM approach seeks to manage the distribution of all anthropogenic interventions that affect marine ecosystems (Jones, 2014).

### **International legal framework**

The United Nations Convention on the Law of the Sea (UNCLOS) is the basic instrument of the entire legal framework for activities at sea. This emerges as a need for the improvement and protection of the marine environment (Jones, 2014). To this end, Part XII of the Convention contemplates the rules for the protection of marine ecosystems and their sustainable use. Particularly, in Articles 194 and 211 it establishes provisions related to the protection of ecosystems through the establishment of special areas. This was the starting point for the development of legal instruments, such as the Convention on Biological Diversity (CBD Acronym in English) which establishes the implementation of the MPAs and defines the global objectives for the restoration of degraded ecosystems in 15 % of the oceans (CBD, 2016). Likewise, institutions such as FAO, UNESCO and IMO determine the mechanisms for the establishment of MPAs (Rueda, 2016).

In order to manage and conserve areas of ecological importance, MPAs emerge as a

viable and effective solution for the protection of habitats that are being threatened by impacts resulting from local and transnational maritime activities (Kelleher, Bleakley & Wells, 1995). Environmental institutions such as the International Union for Conservation and Nature (IUCN) and the United Nations Environment Program (UNEP acronym in English) play an important role in the designation of MPAs, guiding countries in the election and administration process (Van Tatenhove, 2013, Jones, 2014, Wright, 2014, Marine Conservation Institute, 2015).

Currently, the 2030 Agenda of the Sustainable Development Goals (SDGs), through Goal 14, seeks to "Conserve and make sustainable use of the oceans, seas and their marine resources for sustainable development" (UNSD, 2015, pág. 26). To achieve this it was established that by 2020 there must be an increase, of up to 20 %, of the oceans protected by MPAs, compiling in one goal the objectives that the other legal instruments seek to achieve. In addition, the plan seeks to improve cooperation mechanisms between coastal states. Under this same premise, the IMO establishes legal mechanisms and instruments related to the protection of marine ecosystems from the impacts of maritime traffic, through the establishment of special areas.

### **Legal framework of the IMO in the governance of MPAs**

IMO through the Convention for the Prevention of Shipping Pollution (MARPOL 73/78) is contributing to the protection of the marine environment from the impacts caused by marine activities, through mechanisms associated with MPAs. Therefore, under Resolution A 720 (17) they established the Guidelines for the Designation of Special Areas and the Identification of Particularly Sensitive Sea Areas (PSSAs) (Blanco-Bazán, 1996, IMO, 2016). This has been an effective solution for the exclusion or limitation of specific activities in areas at high risk due to maritime traffic, counteracting the degradation of marine habitats due to adverse effects caused by passing ships.

On the other hand, in relation to MARPOL 73/78, 25 States of the GC are part of the said Convention, considering themselves an important number for the protection of the environments in the area. Also, in 2011, the GC became a Special Designation Area under Annex V of said convention, which prohibits the unloading of any type of garbage by ships (CEP, 2011). Therefore, countries must make use of said treaty and comply in relation with the protection of the environment.

### **Regional legal framework of the MPAs**

The Greater Caribbean (GC) is recognized as one of the most complex and particular areas in the world (UNEP, 2014b). Twenty-eight coastal and island states, with more than one hundred maritime borders, enclose this vast area (UNEP, 2012, UNEP, 2014a, CEP, 2015), constituting it a geographically and politically diverse area. The regional legal framework for governance is monitored through the United Nations Environment Program (UNEP) with the Caribbean Environment Program (CEP) (UNEP, 2014b). Under this program, the only binding agreement was established more than forty years ago, called the Convention for the Protection and Sustainable Development of Marine Environments in the GC, (hereafter the Cartagena Convention) and its three Protocols (UNEP, 2012; UNEP, 2014a).

Considering that the countries in the area are in the category of developing economies, marine ecosystems are threatened by the increase in anthropogenic activities, as well as weaknesses in compliance with the regional legal frameworks. Therefore, the establishment of MPAs is one of the major objectives in this area as a mechanism for the conservation of the biodiversity. For this, the Protocol Concerning Specially Protected Areas and Wildlife (SPA) aims to "take the necessary measures to protect, preserve and manage, in a sustainable manner, areas that require special protection to safeguard their particular value, and where there is a threat to damage species of flora and fauna "(Art 3) (UNEP, 2012).

Currently, only 31 MPAs have been established in nine coastal states of the GC

under the SPAW Protocol; the total protected area is 100 000 km<sup>2</sup>, corresponding to 4% of the entire Caribbean (CEP, 2015). However, the SPAW Protocol has only been ratified by 16 states, including Colombia (UNEP, 2014a).

### **Colombia and Governance in the MPAs**

Colombia is one of the countries with the greatest biological diversity and one of the oldest environmental legislations in Latin America (Cajiao, *et al.*, 2006, "US Commerce Office", 2011). Its maritime jurisdiction encompasses rich ecosystems of coral reefs, seagrasses, mangrove forests and coastal lagoons (The World Bank, 2006, "US Commerce Office", 2011, Minambiente, 2016), covering a total of 561 235 hectares (Alonso, and others, 2015), contributing to the national economy, based mainly on ecosystem services, which has seen considerable growth in recent years (Nolet, Vosmer, De Brujin & Braly-Cartillier, 2014), and which represents 40% of the Gross Domestic Product (OHI, 2015).

The principles and provisions for the protection and management of the nation's natural resources are established in the National Constitution of 1991 (Minambiente, 2011, OECD, 2014). Likewise, within this, the Nation has as its premise compliance with international treaties; therefore, it has adopted and implemented the CBD, MARPOL 73/78 since 1981 and the Cartagena Convention in 1987, and others that are related to the protection of the marine environment (Minambiente, 2011). In addition, since 2007, the country has defined the National Ocean and Coastal Space Policy as the roadmap "for the development and promotion of national maritime interests through effective and harmonious integration among the actors in charge of its execution". For this purpose, it defines six specific objectives, among which are:

*Establish a marine-coastal order that allows the different visions, policies, plans, programs and actions on the territory to be compatible, seeking a harmonious and integrated spatial development within the framework of governance, which provides well-being and generates security conditions*

for coastal populations. "And" Generate the necessary conditions to maintain a healthy marine-coastal environment and promote the conservation and sustainable use of resources "(CCO, 2014, page 57).

National legislation on MPAs is based on the guidelines outlined in current international instruments. The classification and protection categories of MPAs take into account the categories established by IUCN (Lausche, 2011, Al-Abdulrazzak & Trombulak, 2011). Currently, eleven categories of protection have been established for the protection of ecosystems at national level (Minambiente, 2012, pp. 9-10). Only under six of these categories, the country has 9% (7854 381.83 hectares) of its maritime jurisdiction protected by MPAs (PNNC-RUNAP, 2016), where only 16 % of marine ecosystems are protected by 23 MPAs, one of these is the National Integrated Management District of the Seaflower Biosphere Reserve in the insular area

of the Archipelago Department of San Andrés and Providencia (Howard, 2006, CEP, 2015, PNNC-RUNAP, 2016).

### The Seaflower MPA

The Archipelago of San Andrés and Providencia comprises three small inhabited oceanic islands and eight cay islands and unpopulated atolls, the largest of which is San Andrés located 800 km (480 m) northwest of the Colombian continental area (UNEP, 2010; Murillo & Ortiz, 2013). These enclose the largest coral reef ecosystems in the country (INVEMAR, 2016), as well as marine pastures and mangrove forests, which offer habitat to various vertebrate marine species, mollusks, and migratory species (CORALINA-INVEMAR; Gómez-López, DI, Segura-Quintero, C., Sierra-Correa, PC, Garay-Tinoco, J., 2012). The MPA covers a marine area of 65 000 km<sup>2</sup>, with only 1 % of land area (650 km) (UNEP, 2010).

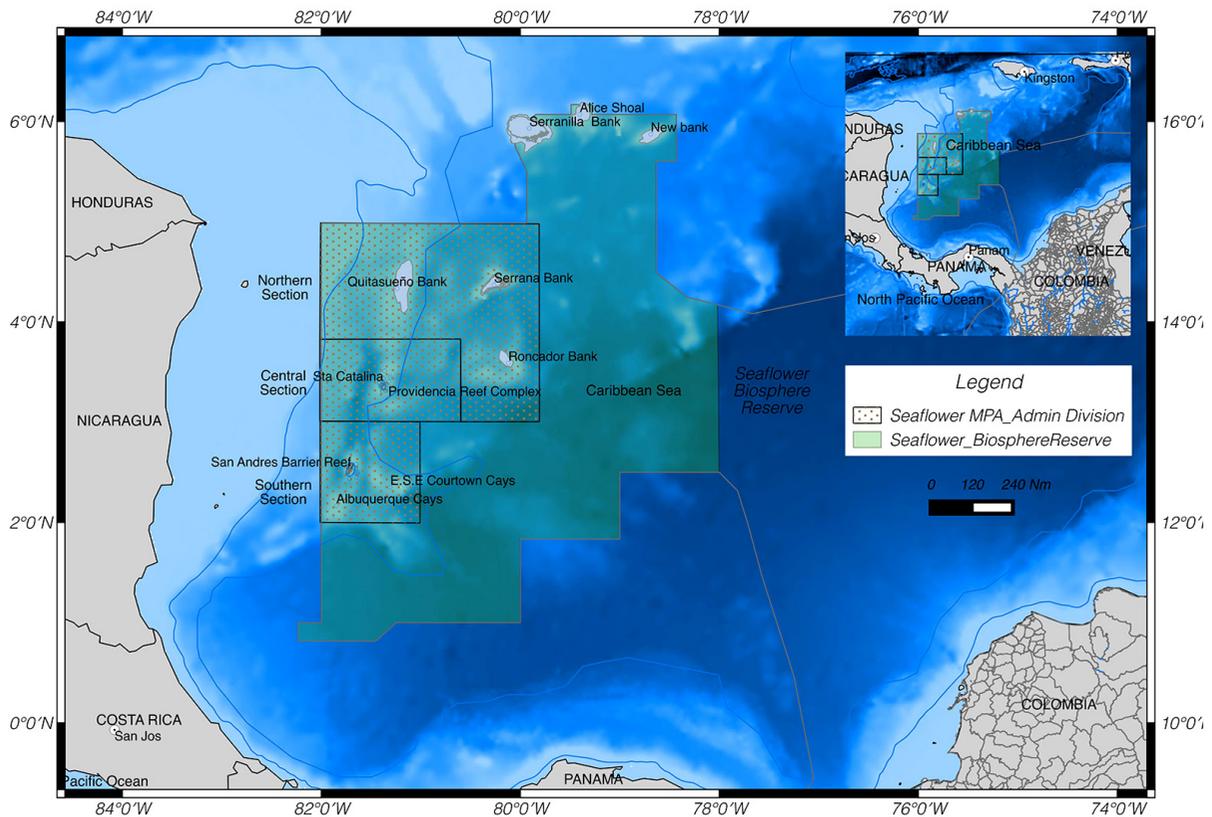


Figure 1. MPA Jurisdiction and the Seaflower Biosphere Reserve.

Oceanographic conditions are complex environments, which are well described by Andrade (2000) and Coralina-Invemar; Gómez-López, D.I; Segura-Quintero, C; Sierra-Correa, P.C.; & Garay-Tinoco, J., (2012). These particularly complex conditions have contributed to the formation and evolution of a unique coral reef ecosystem in the region, which serves as a habitat for various species of marine fauna and flora.

Since 1998, the Colombian government, in its concern for the protection of marine ecosystems, proposed the designation of the Archipelago of San Andrés, Providencia and Santa Catalina, as well as its surrounding marine area as a biosphere reserve (Figure 1), calling it Seaflower (Minambiente, 2005). At the end of 2000, because of its importance and biological diversity, UNESCO declared it within the global biosphere network (Howard, 2006). The national government in turn, designated in 2005, through resolution 107 of the MADS, the MPA within the biosphere reserve (Minambiente, 2005). Currently, it is the largest MPA in the Caribbean Sea and the first of its category in Colombia (Howard, 2006, UNEP, 2010, Coralina-Invemar, Gómez-López, DI, Segura-Quintero, C.; Sierra-Correa, PC Garay-Tinoco, J., 2012; Taylor, Baine, Killmer & Howard, 2013).

The regional environmental authority in charge of its administration and management is the Regional Autonomous Corporation of the Archipelago - Coralina, who based on the EBM and MSP approaches, in coordination with the communities and different authorities in the area, defined an administrative zoning, through the Agreements 021 and 025 respectively. Under these agreements, three administrative zones (north, center and south) and five zones for in-situ conservation and sustainable use were established as follows: Intangible (116 km<sup>2</sup>); Untouchable (2214 km<sup>2</sup>); Recovery and sustainable use of marine resources (2015 km<sup>2</sup>); Special uses (68 km<sup>2</sup>), related to maritime activities; and of General Use (60587 km<sup>2</sup>), where minimum restrictions apply (Howard, 2006, Taylor, Baine, Killmer & Howard, 2013). All of these seek to maintain and meet the objectives of the MPA. These measures are complementary to those established under the Biosphere Reserve, and facilitate its administration and

management. The main objective of this MPA is to ensure the protection of ecologically relevant areas, preserving the ecosystems and habitats vital for marine life (Coralina, 2005).

The zoning meets the ecological criteria for marine reserves, based on the representativeness and connectivity of key habitats (Roberts, *et al.*, 2003). Therefore, coral reefs constitute the key ecosystem for the conservation of the MPA, these being one of the largest ecosystems in the Caribbean, with an extension of approximately 2000 km<sup>2</sup> (Taylor, Baine, Killmer & Howard, 2013), representing around 14 % of the world's coral reefs (UNEP, 2005), the second in the Western Hemisphere and the most productive in the region (UNEP, 2010). This coral ecosystem is composed of two reef barriers, five atolls, reef lagoons and coral banks (Howard, 2006), which comprise 78 % of those existing in the national territory (Coralina-Invemar, Gómez-López, DI, Segura-Quintero, C., Sierra-Correa, PC, Garay-Tinoco, J., 2012). Additionally, the area has a presence of seagrasses across 2000 hectares, covering 5 % of the extension of the archipelago; and Mangrove forests covering 250 hectares. For this reason, the MPA is considered one of the most biologically productive regions in the area (UNEP, 2010).

To conserve these ecosystem riches, Coralina defined five key objectives for its sustainable management, in which islanders and others participated, applying the EBM (Howard, 2006, De Pourcq, and others, 2015). These objectives were defined taking into account social and ecological criteria to maintain the sustainability of the entire archipelago (Howard, 2006, Taylor, Baine, Killmer & Howard, 2013).

Despite all the measures adopted under Colombian law, by environmental institutions, and the international treaties for the protection of ecosystems, the zoning, and objectives that focus on activities related to fishing and tourism, these remain ineffective. The ecosystems continue to be threatened by problems related to maritime activities, especially those associated with maritime traffic that do not directly interfere with Marpol Annex V in relation to the dumping of garbage, as this area became a Special Designation Area under that Annex in 2011.

### Regional Threats to the MPA

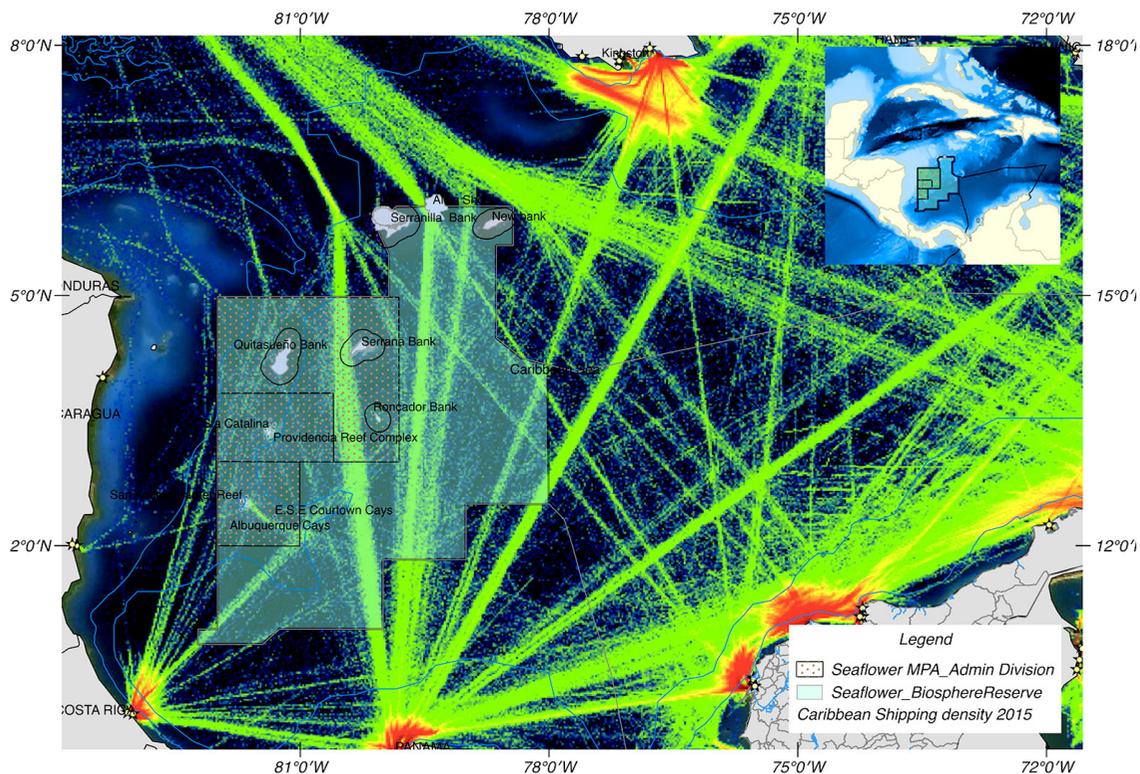
Vallega (2002), UNEP (2005), Lopez & Krauss (2006), Fanning, *et al.*, (2007), Biggs (2009), Morris (2012), and UNEP (2014a) provide a detailed description of current threats and problems affecting marine ecosystems in the GC region, which directly affect the Seaflower MPA. Next, those related to maritime traffic will be described.

### Increase in Maritime Traffic

Latin America and the Caribbean are the area with the highest shipping connectivity, especially with Panama, which as a maritime pivot moves close to 60 % of global trade (IMO, 2012). This has grown by 30% in recent years, increasing routes and connectivity between ports (AGCS, 2014). Thus, to date, 21 maritime operators connect the United States through the Panama Canal, this being the maritime highway of the routes east-west and north-south of America, followed by Mexico, Jamaica,

and Colombia (Unctad, 2015). Therefore, the expansion of the Panama Canal will force the regional expansion of ports and, therefore, large merchant ships will sail the Caribbean Sea (The World Bank, 2016), approximately 4750 additional ships per year, handling about 5 % of all the goods of the world, and covering about 8 % of global shipping (Rodriguez y Ashar, 2015).

On the other hand, according to the US Department of Transportation (2013), Webster (2015) and AGCS (2014), 72 % of the entire regional shipping between Central and South America moves across the Southwest Caribbean, approximately 60 trips per week (14000 annually) along a hundred different sea routes that pass through the Caribbean Sea (Figure 2), with container ships and freighters (petroleum) being the main types of vessels that transit. These movements are divided into intercontinental and regional inter-island traffic (Briceño-Garmendia, Bofinger, Cubas & Millan-Placci, 2015, Unctad, 2015).



**Figure 2.** Density of maritime traffic routes in the Caribbean Sea, 2015.

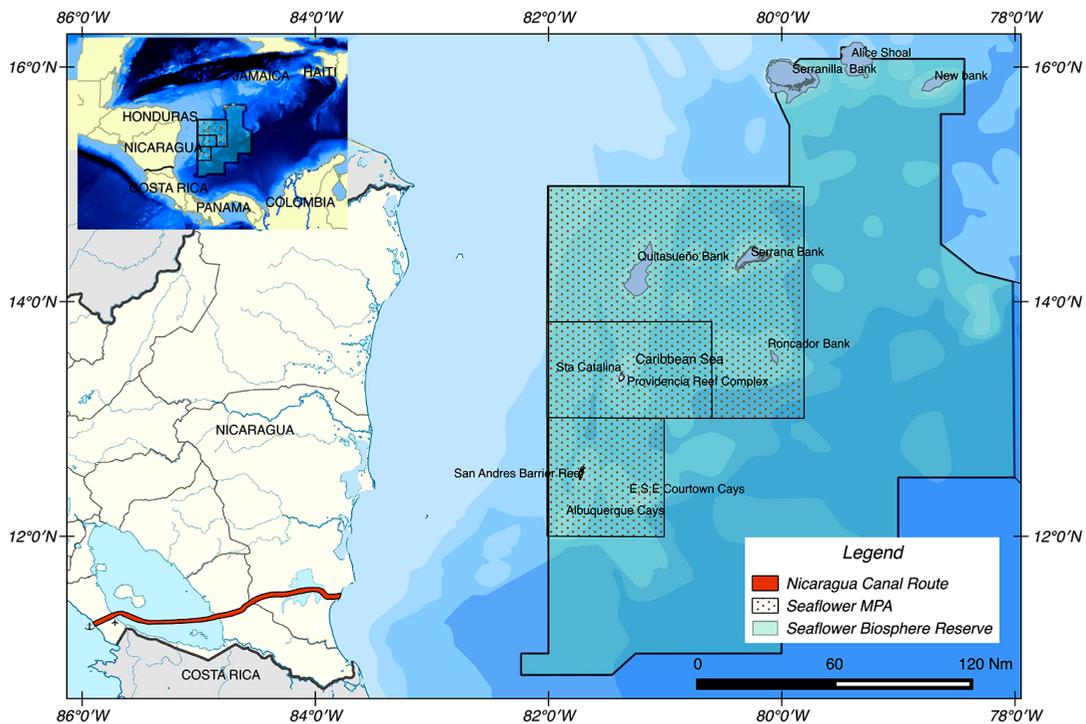
As a consequence, the risk of the occurrence of maritime incidents is high, in addition to the increase in pollution, produced by this traffic (Harrould-Kolieb & Herr, 2012, Hassellöv, Turner, Lauer & Corbett, 2013, Unctad, 2015) which is affecting coral reefs in the Caribbean (Jackson, Donovan, Cramer & Lam, 2014). To this recent increase in traffic through the Caribbean, a greater increase in the passage of ships is envisaged with the project of the New Interoceanic Canal of Nicaragua.

### Nicaragua Canal Project

The Nicaragua Canal seems to be a reality. Since 2013, after several debates within the country's government, the concession was awarded to the Chinese corporation, Hong Kong Corporation (HKND), for the construction of the interoceanic canal, including an oil pipe line and two ports of deep waters, among other projects on land. However, since the start of the concession, no environmental impact study was released for its development, despite the recommendations made by the Nicaraguan

scientific community (Huete-Pérez, *et al.*, 2015; Yip & Wong, 2015 ).

It is estimated that the development of this alternative route will enable the transit of about 17 % of global shipping (AGCS, 2014). This means an increase in maritime traffic near the Seaflower MPA (Figure 3) due to the proximity to the Nicaraguan coasts, about 100 km away (Howard, 2006). Therefore, this project represents a big negative impact, in the medium term, for the focus of biodiversity in the Caribbean (Huete-Pérez, *et al.*, 2015). According to the preliminary analysis of scientists and organizations at national level, the opening of a channel in the continent will change particularly the oceanographic patterns and physical properties of water. This is due to the exchange of fresh water, altering the balance of sea temperature and salinity, drastically changing the composition of water masses, both superficial and deep, especially in semi-enclosed seas such as the Caribbean (Stewart, 2003; Osborne, Haley, Hathorne, Flögel & Frank, 2014).



**Figure 3.** Localization of the Nicaragua Canal.

In addition, during the construction process and future maintenance activities, which require movement and deposition of dredged material along the coasts and shallow waters, will contribute to an increase of particulate matter in suspension, affecting turbidity and water quality due to the effect of currents.

The consequences for the Seaflower MPA will be the degradation and disappearance of coral reefs, especially those near the construction area, as well as damage to seagrasses and mangrove ecosystems, among others (Huete-Pérez, *et al.*, 2015).

### **Environmental problems caused by ships**

All these developments involve greater movement of vessels in the area, which bring negative impacts due to the effects caused by the ship itself, threatening the ecosystem. As is known, 12 % of marine pollution is produced by ships (Romero, 2016). However, the problems caused by the traffic of ships in specific zones are: invasive species, impacts due to the wake generated (Wave wake) and underwater noise.

### **Invasive species**

The problem of invasive species is global. IMO, as the regulator worldwide, has developed mandatory legal instruments and recommendations to deal with it; these are the Anti-fouling Convention (AFS), and the guide to prevent the problem of invasive species (Tamelander, Riddering, Haag & Matheickal, 2010). Additionally, the Convention for the Management of Ballast Water (BWMC Acronyms in English) will enter into force in September 2017, addressing this problem extensively. On the other hand, non-governmental environmental entities are also contributing to this issue by advising and raising awareness within the coastal communities of developing countries, through education programs for the conservation of biodiversity (WWF, 2009).

In the Caribbean Sea, the permanent maritime traffic that passes through the Panama Canal, and that could pass through the Nicaragua Canal, will increase the risk of invasive species due to the exchange of ballast

water and incrustations on the hulls of ships. The negative impacts associated with this phenomenon are well explained by Tamelander, Riddering, Haag & Matheickal (2010). The biggest concern is changes in ecological cycles, which are affected by water quality and impact on coastal communities (WWF, 2009). These changes may be imperceptible in the short term, however, over time these will be more marked and threaten marine environments, altering and changing the stability of ecosystems, especially primary production, and having serious consequences in the economy of the region (Mooney, 2005).

Colombia, as a coastal state, is committed to the implementation of the measures of the Ballast Water Convention, and is a benchmark in the region. The country has developed the appropriate legislation, implementing it through the National Maritime Authority to comply with the mandate of the IMO. For this reason, through the Center for Oceanographic and Hydrographic Research of the Caribbean (CIOH) and in coordination with Invemar, preliminary studies have been carried out to determine the baseline invasive species on the Colombian Caribbean coast (Cañon Paez, Lopez Osorio & Arregoces Silva, 2010; Invemar, 2016) and maintain constant monitoring for their management and mitigation.

For the Seaflower MPA, the largest invasive species that is affecting the ecosystems within this area is the invasive species "Lionfish" (Mooney, 2005, Green & Côté, 2008, Morris, 2012). Although its inclusion was not caused by ballast water (Mooney, 2005), its dispersion at present can be influenced by this activity, increasing the risk of displacement of fish species in the area due to the high traffic passing through. This is because the main route that comes from the North Caribbean and goes to Panama passes through the MPA. In addition, the risk of interchange of ballast water during transit is latent and may cause the inclusion of non-native species in the area. Therefore, the participation of all the coastal countries of the region is imperative to control this invasion and thus avoid massive degradation of native ecosystems.

### **Waves caused by Ships wake (Wave Wake)**

To discuss the impacts of the waves generated by the passage of ships, it is necessary to consider the concept of high-speed vessels defined by the IMO in the High Speed Ship Code (HSC Code Acronym in English). A high-speed vessel is "one whose maximum speed is equal to or greater than  $3.7 \nabla^{0.1657}$  (m / s), where  $\nabla$  (m<sup>3</sup>) equals the displacement of the ship measured above the water line" (MarCom, 2003). In this sense, merchant ships are within the categorization of high-speed vessels (UK Legislation, 2004).

Wake waves, associated with the passage of merchant ships, produce two identified dominant effects, which have negative effects on the environment. The first one is the one produced by the change in the period of the wave due to the speed of the ship; the second is the transformation of the height of the wave caused by the effect of the bathymetry (MarCom, 2003). These two effects can cause significant changes in the morphology and, therefore, in the ecology of the area where it occurs due to the constant transit of large merchant ships at a steady speed (Moon & Woo, 2014), as well as the passage of small boats at high speed, especially in areas where the wave's natural energy is very low (Bauer, Lorang & Sherman, 2002). These two processes produce greater effects in archipelagic island areas such as the Seaflower MPA, because changes in the bathymetry resulting from the morphology of coral ecosystems, cause degradation of the reefs as well as changes in the coastline. Due to local seasonal oceanographic patterns, the effects of the swell of the wake cause drastic changes in the height, regularity, and direction of the waves, affecting the physical and biological conditions of the ecosystems. Therefore, the increase in maritime traffic due to the expansion of the Panama Canal and the possible Nicaraguan Canal, can cause greater negative impacts on marine environments in the MPA as a result of the wake waves.

### **Underwater noise caused by ships**

Underwater noise has been extensively studied, at present, due to the impacts on the marine environment. Maritime activities such as the transit of ships, exploration of the subsoil, and the use of structures for the generation of renewable energies are the main sources of noise that are present in the ocean (Abdulla & Linden, 2008). The values have increased almost double in the last decade, being proportional to the increase in the size of the vessels (Mazzuca, 2001, cited by Haren, (2007).

Studies conducted by Harren (2007), McKenna, Ross, Wiggins & Hildebrand (2011) confirm that the noise produced by merchant ships is categorized as chronic low level. Super tankers and container ships are in the classification of those that emit the largest wide bands of low frequency tones (long distance waves) between 5 and 500 Hz. This is a characteristic of the waves generated by cavitation resulting from the interaction of the propellers with the water; and in addition the noise produced by friction, generated by the large scale displacement of the ship, and is classified as constant low frequency emissions. Due to the above, considering the absorption capacities of seawater, these sounds can endure within the marine environment for long periods due to the constant disturbance caused, which is a threat to species due to its cumulative effect over time.

Therefore, the increase in maritime traffic in the western Caribbean will proportionally increase the levels of underwater noise interfering with the species in their communication ability, affecting reproductive functions, and locomotor development due to stress generated by noise. In addition, as in other areas of the world, it causes massive losses in mammals due to collisions with large merchant vessels (Hildebrand, 2005). Due to this problem, the International Whaling Commission (IWC) and the IUCN are leading the adoption of measures to protect marine species and environments from noise produced by ships, especially in MPAs (Haren, 2007; Abdulla & Linden, 2008).

Likewise, the IMO in its concern with this problem, in 2014 published within the document MEPC.1 / Circ.833, the *"Guidelines for the reduction of underwater noise produced by commercial maritime transport to mitigate the adverse effects on marine life"*(IMO, 2014). These measures have a direct impact on the implementation of new technologies, good maintenance practices for ships and marine structures, and the selection of an optimal speed that reduces noise. Also, this Guide advises countries on the adoption of MSP measures such as redirecting maritime routes to reduce adverse effects on marine life, especially in sensitive areas.

Studies conducted by Poleika, S., (2004) cited by Haren, (2007), in 2004, at the National Marine Sanctuary Canal de Santa Bárbara, on the Pacific coast of the USA, show that the noise generated by the propellers of merchant ships had the most significant impact in the Sanctuary area due to the proximity of the routes that passed through it.

In the context of the Seaflower MPA, the increase in maritime traffic in the area due to recent regional developments will result in a higher density of ships passing through, which will threaten the ecosystems that are within the MPA due to the resilient noise, causing the degradation of coral species and fish migration over time.

## **DISCUSSION**

According to all that has been expressed in the previous paragraphs, the greatest threats within the Seaflower MPA are transnational in nature due to the development of maritime activities, especially the increase in maritime traffic. Consequently, while ships continue to exercise activities in the world's waters, the different forms of pollution produced by them will continue to contribute to the degradation of biodiversity in the oceans and this is no different in the Colombian jurisdiction. Therefore, it is necessary to take effective measures at all levels.

According to the public consultation on international ocean governance carried out by the European Union in 2015 (EU, 2015), the legal framework in regional seas was evaluated as ineffective. However, to mitigate the problems related to regional maritime transport, it is necessary to take protective measures based on international environmental and regional treaties in which Colombia is a party since they enable the efficient administration of the maritime jurisdiction in which other States are involved, where the maritime activities that take place affect the ecosystems of the Seaflower MPA.

To achieve this, it is important that the country makes use of the constitutional principles of protecting biodiversity and ecosystems, as promulgated by the national constitution and environmental legislation. In this regard, in order to achieve the objective of protection, the country must consider the application of the EBM approach in combination with the MSP, through which it is possible to manage our marine resources in a sustainable manner. This approach must be implemented by the Maritime Authority and national environmental organizations, making use of cooperation and coordination mechanisms established by the UN, IMO and UNEP to involve neighboring countries in the protection of ecosystems. It is important to understand that living marine resources do not know or attend to political limits and that is why we must seek international cooperation for the adoption of effective governance in the protection of the marine environment.

Taking into account activities related to maritime traffic, the Seaflower MPA is the appropriate area, due to its location in the Western Caribbean, for the implementation of transboundary protection measures. For this it is important to implement management and governance mechanisms to fill in the existing gaps between the national and international legal framework. It is important to understand that the governance process must be developed in two ways, from top to bottom and from bottom to top, as expressed by Jones (2014). This can be achieved by involving all the actors, government, merchants, and local and regional communities, who cause interference within

the MPA, seeking effective integration through a participatory process of all those who benefit from ecosystem services in the area.

To ensure the conservation of ecosystems within the MPA, it is necessary to consider MPH measures that improve the existing zoning and that contribute to the management and handling of MPAs, which, in combination with the EBM approach, will be useful in resolving inter-sectoral and borderland conflicts, as expressed by Olsen, *et al.*, (2013) and Ehler (2014). Therefore, to mitigate the impacts produced by maritime activities related to maritime traffic, the most viable solution that can be effective is the application of preventive measures developed by the IMO for the regulation of maritime traffic and the protection of ecosystems, such as the establishment of PSSA and the creation of Traffic Separation Schemes (TSS).

PSSAs, as expressed by Spadi (2000) and OMI (2006), are a preventive measure concept established by IMO to mitigate the adverse effects of the interaction between ships and the environment. This concept is proposed within the legal framework of the protective measures defined in MARPOL 73/78 (Blanco-Bazán, 1996, Roberts, Tsamenyi, Workman & Johnson, 2005), which are framed in accordance with the guidelines on routing and the cooperation that must exist between states for their development (IMO, 2003).

For the IMO to agree to declare a PSSA, the designated area must meet certain criteria for its designation, at least one of the following three elements defined by Roberts, Tsamenyi, Workman & Johnson (2005):

- That the proposed area be relevant in one of the three basic concepts (ecological and social, cultural and economic, and / or scientific - educational);
- It must require special protection, that is, be sufficiently vulnerable to impacts by international maritime traffic and;
- That the area allows the IMO to take the appropriate and pertinent actions

within the scope of its legal framework to provide protection against the vulnerability already identified..

Additionally, the area to be designated must provide historical evidence of the risks and impacts (damages) caused by and to the vessels, taking into account the relevant natural factors and maritime traffic characteristics. On the other hand, there are other considerations that should be discussed between coastal states, IMO and international environmental organizations through cooperation mechanisms, in which all must unanimously express their interest in protecting the area, and that restrictive measures outside the scope of the IMO do not affect maritime activities (Blanco-Bazán, 1996).

To ensure the effectiveness of protectionist measures, states can implement Associated Protectionist Measures (APMs) to PSSAs (IMO, 2006, Guan, 2010). These measures are related to mandatory or recommended piloting, mandatory reporting of vessels, restricted areas (avoid), prohibited discharges, prohibited areas for anchoring, deep water routes, and Emission Control Areas (ECA) (IMO, 2006).

According to Gjerde (2001), the benefits are evident with the designation of PSSAs. The first is the safety of navigation and the protection of ecosystems since, being marked on the nautical charts, it obliges ships that sail in the vicinity to take the necessary precautions in accordance with the APMs; second, the designated area acquires international recognition, so any additional action taken to protect this area acquires significant value and must be complied with by all the actors. Therefore, the coastal states that have these delineated areas under their jurisdiction can take additional measures to mitigate the threats and risks associated with maritime activities in the area.

On the other hand, the IMO has defined the Maritime Traffic Separators (STM) as an effective proposal for the management of the traffic of large merchant ships within a particular area, promoting safety in navigation and efficiency in the operation of ships. This is to promote the protection of marine,

physical and biological resources (Brown, 2001, Pietrzykowski & Magaj, 2016). STMs are applied, in principle, to tankers, bulk carriers, and large container ships (Brown, 2001). For its good and effective operation, a robust Maritime Traffic System (VTS) is required, through which effective control and monitoring of the delineated maritime highway is carried out (IMO, 2003).

In this sense, the STMs are applicable to MPAs due to the level of protection they provide for the proper functioning of maritime transport. That is why the coastal states have the obligation to take the necessary preventive measures in order to protect their ecosystems within the maritime jurisdiction, including the partial or total exclusion of vessels from MPAs (Spadi, 2000).

The effectiveness of STMs has been measured and proven around the world. The Baltic Sea, one of the most congested areas by maritime traffic in the world (EU, 2013, Pietrzykowski & Magaj, 2016) has these control mechanisms and the benefits have been proven with a significant reduction of collisions in the most congested areas like the English Channel. In addition, it has contributed to the protection of the environment, since by controlling the transit speed of large vessels, the reduced effects of wake waves and underwater noise during the passage through protected areas have positively influenced the restoration and conservation of species in danger of extinction (Silber *et al.*, 2012). Likewise, this mechanism has been implemented and evaluated in MPAs such as the National Marine Sanctuary in the Bay of Monterey, USA (Brown, 2001), and in the Pelágos Sanctuary in the Mediterranean Sea with positive results where deaths have been significantly reduced in mammals and cetaceans due to collisions with transiting vessels (Coomber *et al.*, 2016).

In the Caribbean Sea, the new Panama Canal, and the proposed Nicaragua Canal, promote the connectivity of the world's shipping companies, causing an increase in traffic in the area. It is estimated that the largest flow of vessels will be to the southwest of the Caribbean Sea, where the Seaflower MPA

is located. According to the US Department of Transportation (2013) and Webster (2015), the ships tracked through the AIS system in the Caribbean area (Figure 2), and passing through the Seaflower MPA, are mostly large container carrier vessels, bulk carriers (oil), in addition to tourist cruises. This represents a challenge for the National Maritime Authority - DIMAR - and for the other authorities in the region, in the preparation and adoption of measures that contribute to mitigate the effects of this increase in maritime traffic in the region.

Therefore, to mitigate the effects of maritime traffic within the Seaflower MPA it is imperative to establish PSSAs with their respective AMPs following the guidelines defined by the IMO.

## RECOMMENDATIONS

In order to protect the ecosystems within the Seaflower Biosphere Reserve and the MPA, Colombia must strengthen good political relations with neighboring countries as a strategy to implement the cooperation mechanisms invoked by the UN through existing legal instruments, as the only means for sustainable development. This is the first step in order to invite and commit the neighboring states of this important marine area, to protect the marine environment. The materialization of this commitment will be corroborated with the ratification of the SPAW Protocol, seeking that the countries of Costa Rica, Nicaragua, and Honduras comply with the obligations included in this protocol, and that have a direct impact on the protection of the Seaflower Biosphere Reserve. Within this process, the participation, as advisory and decision-making entities, of the governmental and scientific entities of the country, such as the Colombian Ocean Commission (CCO), the Ministry of Environment and Sustainable Development, INVEMAR, as well as the autonomous corporation of the archipelago- CORALINA, is decisive. This will provide an objective and accurate vision of the measures that are implemented, and which, being integrated and coordinated at the local level, at regional level have the same level of coordination to guarantee its effectiveness.

Regarding the regulation of maritime traffic and the protection of ecosystems in the area, Colombia must initiate the corresponding studies with the purpose of gathering the necessary scientific information to present before the IMO and request the designation of PSSAs with their respective AMPs. The areas recommended are those which, according to Figure 2, have the highest density per ship passage; that is, the northern part of the MPA, in the Cayos de Quitasueño, Roncador, Serrana and Serranilla Islands. According to Murillo & Ortiz (2013) the cartographic and morphological information of this area of the MPA meets the IMO criteria, defined by Roberts, Tsamenyi, Workman & Johnson (2005), for the designation of these special areas, since it has the largest concentration of coral reefs, which represent a high risk for navigation as observed on the nautical charts of the area with the wrecks that have occurred over time.

It is recommended that the PSSA have an area (buffer) of 7 nautical miles (Figure 4) measured from the fringing edge of each Cay island. This measure is determined taking into account the experience and proven effectiveness with the PSSA on the Island of Malpelo in the Colombian Pacific Ocean, declared by IMO in 2005 (Cajiao, *et al.*, 2006). This distance is considered sufficient to ensure that the impact caused by wake waves, generated by the passage of merchant ships in the area, is minimal. Also it does not restrict navigation in the area by overlapping the areas between the Cay Islands, and with this buffer, the direct effects caused by noise that could be generated by traffic in the area are reduced

Additionally, for each PSSA that is created, the establishment of AMPs such as STM, avoidance areas and non-anchoring areas is appropriate. These measures can be implemented in these areas of the MPA, complementary to those which, according to the zoning, are of general use. The implementation of these zones will guarantee the protection of corals in the MPA. In addition, in order to monitor these measures, it is necessary to strengthen the VTS in San Andres Island. To do this, as an additional measure of monitoring, in the Cay Islands, radars and AIS systems can

be implemented to monitor the area, providing greater coverage for the VTS of San Andrés. The above is feasible considering that each one of the aforementioned islands are inhabited by personnel of the Colombian Navy who for some time, have had the responsibility of enforcing the zoning established for each Cay island.

## CONCLUSION

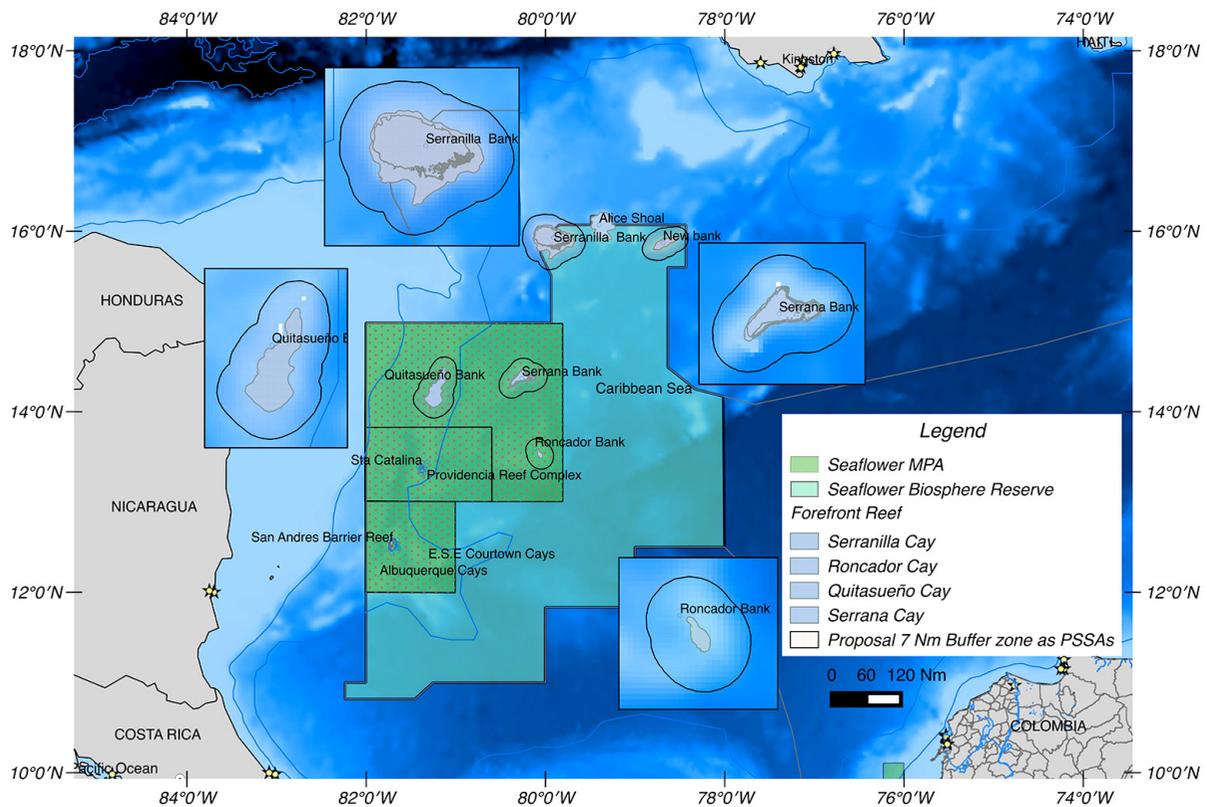
Governance in MPAs requires the participation and cooperation of the actors to achieve their goal. For this it is important to make use of the EBM approaches in combination with the MSP to maximize its effectiveness. This has been analyzed in this document, and added to the international legal framework for the protection and conservation of the ecosystems that are enclosed in these areas, will allow the sustainable development that the world seeks to achieve through the 2030 Plan.

However, the increase in maritime traffic in the Western Caribbean Sea due to the expansion of the Panama Canal, which will be magnified by the possible Nicaragua Canal, forces States to take preventive-proactive measures in order to mitigate the adverse effects that result from this practice. This is why Colombia must submit to the IMO the proposal for the designation of the PSSAs in the northern part of the Seaflower MPA, in the Cay Islands, implementing the relevant AMPs to ensure the conservation and protection of the ecosystems within this important MPA.

These local measures will take effect as long as the country strengthens good political and diplomatic relations and makes use of cooperation mechanisms with neighboring countries seeking compliance with existing regional environmental agreements, with the purpose of protecting ecosystems within the Seaflower MPA. The strategy that the country takes must be framed within the principles of the EBM approach in order to give it the vital value of the ecosystems it seeks to protect, and that are of regional importance for the future of the generations in the region. Finally, it is important to continue strengthening the inter-institutional work between the

different national environmental entities and the maritime authority in order to fulfill the

constitutional mandate of preserving the great biodiversity of our waters.



**Figura 4.** Protective Buffer for the Coral and PSSA zones within the Seaflower MPA.

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