

IS THE CREATION OF A MARINE PROTECTED AREA MANAGED BY THE EMBERÁ INDIGENOUS COMMUNITY AN EFFECTIVE STRATEGY TO REDUCE ILLEGAL BIODIVERSITY TRAFFICKING, IUU FISHING AND HABITAT DESTRUCTION OF 23 THREATENED SPECIES OF SHARKS AND RAYS IN THE COLOMBIAN PACIFIC?

A strategy implemented by **BOSQUE COLOMBIANOS FOUNDATION** and
The Conservation, Food & Health Foundation

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ABSTRACT

Illegal, Unreported, and Unregulated (IUU) fishing and biodiversity trafficking threaten the survival of 23 shark and ray species in the Colombian Pacific. This study evaluates the effectiveness of a Marine Protected Area (MPA), co-managed by the Emberá Indigenous community, as a strategy to combat these threats while promoting sustainable fisheries. The 24,216.33-acre MPA, implemented by Bosque Colombiano Foundation with funding from The Conservation, Food & Health Foundation, sought to reduce IUU fishing, mitigate habitat destruction, and enhance indigenous governance over marine resources.

Over 12 months, the project achieved 92% of its objectives, successfully reducing IUU fishing by 70% within the MPA. Key interventions included: (i) the legal registration of the MPA (95% completed), (ii) the deployment of 25 Emberá park rangers, conducting 8-hour daily patrols over high-risk areas, (iii) the enforcement of 80 management regulations, achieving a 95% compliance rate, and (iv) the replacement of 100 unsustainable fishing kits, reducing bycatch by 40%. The project also trained 300 indigenous fishers, including 50% women aged 18-35, in sustainable fishing practices, increasing local engagement in conservation by 80%.

However, unforeseen challenges impacted project execution. Organized criminal networks overlapped with 200 hectares of the protected zone, requiring field suspensions to ensure personnel safety. Additionally, extreme climate events delayed the installation of 100 conservation signs and disrupted initial patrolling operations. Community resistance to seasonal fishing bans was addressed through participatory workshops, increasing compliance from 60% to 80%.

This case study demonstrates that community-led MPAs are a viable conservation strategy, balancing biodiversity protection, sustainable livelihoods, and indigenous governance. Lessons learned highlight the need for continuous surveillance, technological integration (drones, GIS), and adaptive management to ensure long-term sustainability. These findings contribute to global discussions on indigenous conservation models and the role of MPAs in mitigating IUU fishing.

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INTRODUCCIÓN

Illegal, Unreported, and Unregulated (IUU) fishing and biodiversity trafficking have become critical threats to marine ecosystems, particularly in regions with high ecological value such as the Colombian Pacific. This area harbors 23 shark and ray species classified as critically endangered or vulnerable by the International Union for Conservation of Nature (IUCN), including the scalloped hammerhead (*Sphyrna lewini*), the giant manta ray (*Mobula birostris*), and the tiger shark (*Galeocerdo cuvier*). Over the past decade, IUU fishing and habitat degradation have led to an estimated 35% decline in these populations, exacerbated by weak enforcement mechanisms and insufficient community engagement in conservation strategies.

To address this crisis, community-managed Marine Protected Areas (MPAs) have emerged as a promising model for integrating conservation and sustainable fisheries management. Indigenous communities possess extensive ecological knowledge and have historically managed marine resources through traditional governance systems. However, their formal role in conservation initiatives remains limited due to legal restrictions, economic pressures, and a lack of institutional support. This study evaluates the effectiveness of a 24,216.33-acre MPA, co-managed by the Emberá Indigenous community and supported by Bosque Colombiano Foundation with funding from The Conservation, Food & Health Foundation, as a strategy to mitigate IUU fishing, biodiversity trafficking, and habitat destruction.

The project aimed to reduce IUU fishing by 95%, improve local enforcement capacity, and promote sustainable fishing alternatives through direct community involvement. Key interventions included the legal recognition of the MPA, the deployment of 25 Emberá park rangers conducting 8-hour surveillance patrols, and the implementation of 80 conservation regulations, achieving 95% compliance among local fishers. Additionally, the project facilitated the exchange of 100 unsustainable fishing kits, reducing bycatch rates by 40%, and delivered 50 master training sessions to 300 Indigenous fishers, with 50% female participation.

Despite achieving 92% of its objectives, the initiative encountered significant operational challenges. Organized criminal groups operate within at least 200 hectares of the protected zone, posing safety risks for enforcement teams and requiring strategic field suspensions. Extreme climate events, including prolonged droughts and coastal flooding, disrupted initial monitoring efforts and delayed the installation of 100 conservation signs. Furthermore, community resistance to seasonal fishing bans initially

hindered compliance, necessitating an intensive outreach program that ultimately increased acceptance from 60% to 80%.

This study contributes to the growing body of research on community-led conservation, highlighting the potential of Indigenous governance models in marine protection. By leveraging traditional ecological knowledge, strengthening surveillance capacity, and integrating technological tools such as GIS and drones, this initiative demonstrates that co-managed MPAs can yield measurable conservation benefits while securing livelihood resilience for local fishers. The findings underscore the need for long-term policy support, adaptive management strategies, and international collaboration to enhance the sustainability of community-driven conservation efforts in biodiversity hotspots.



MATERIALS AND METHODS

Study Area

The project was implemented in a **24,216.33-acre Marine Protected Area (MPA)** along the Colombian Pacific coast, within the **Emberá Indigenous territory**. This area is a highly productive ecosystem that serves as a critical habitat for **23 species of sharks and rays**, classified as **vulnerable, endangered, or critically endangered** by the IUCN. The delineation of the protected area considered key breeding, feeding, and migration zones, including coral reefs, mangroves, and estuaries.

Study Design

This study employed a **longitudinal experimental approach**, with measurements conducted in three phases:

1. **Baseline assessment (December 2023 – January 2024):** Initial parameters of biodiversity and illegal fishing activity were established.
2. **Intervention phase (February – June 2024):** Implementation of management and monitoring strategies within the MPA.
3. **Post-intervention evaluation (July 2024):** Assessment of the impact on illegal fishing reduction, biodiversity recovery, and community compliance.



- Replacement of 100 unsustainable fishing kits with selective gear, reducing bycatch by 40%.
4. **Community Training and Awareness Campaigns**
 - 50 training sessions targeting 300 Emberá fishers (50% women, aged 18-35).
 - 10 door-to-door awareness sessions reinforcing acceptance of seasonal fishing bans.
 - Development and distribution of a fisheries management manual to five local schools.
5. **Infrastructure and Environmental Education**
 - Installation of 100 information signs in strategic coastal locations.
 - Distribution of 300 school kits with educational materials on marine conservation.
 - Establishment of the Indigenous Environmental Secretariat, ensuring post-project sustainability.

Data Collection and Analysis

Data collection methods included:

- Monitoring of illegal fishing activity: Patrol and drone records of detected incursions.
- Biodiversity and species recovery assessments: Pre- and post-project visual and acoustic censuses of sharks and rays.
- Socioeconomic indicators: Surveys assessing fishers' income and reliance on illegal fishing.
- Community acceptance: Pre- and post-intervention questionnaires evaluating compliance and perception changes.

Statistical Analysis

Data was processed using RStudio 4.2.2, applying analysis of variance (ANOVA) to assess significant differences in:

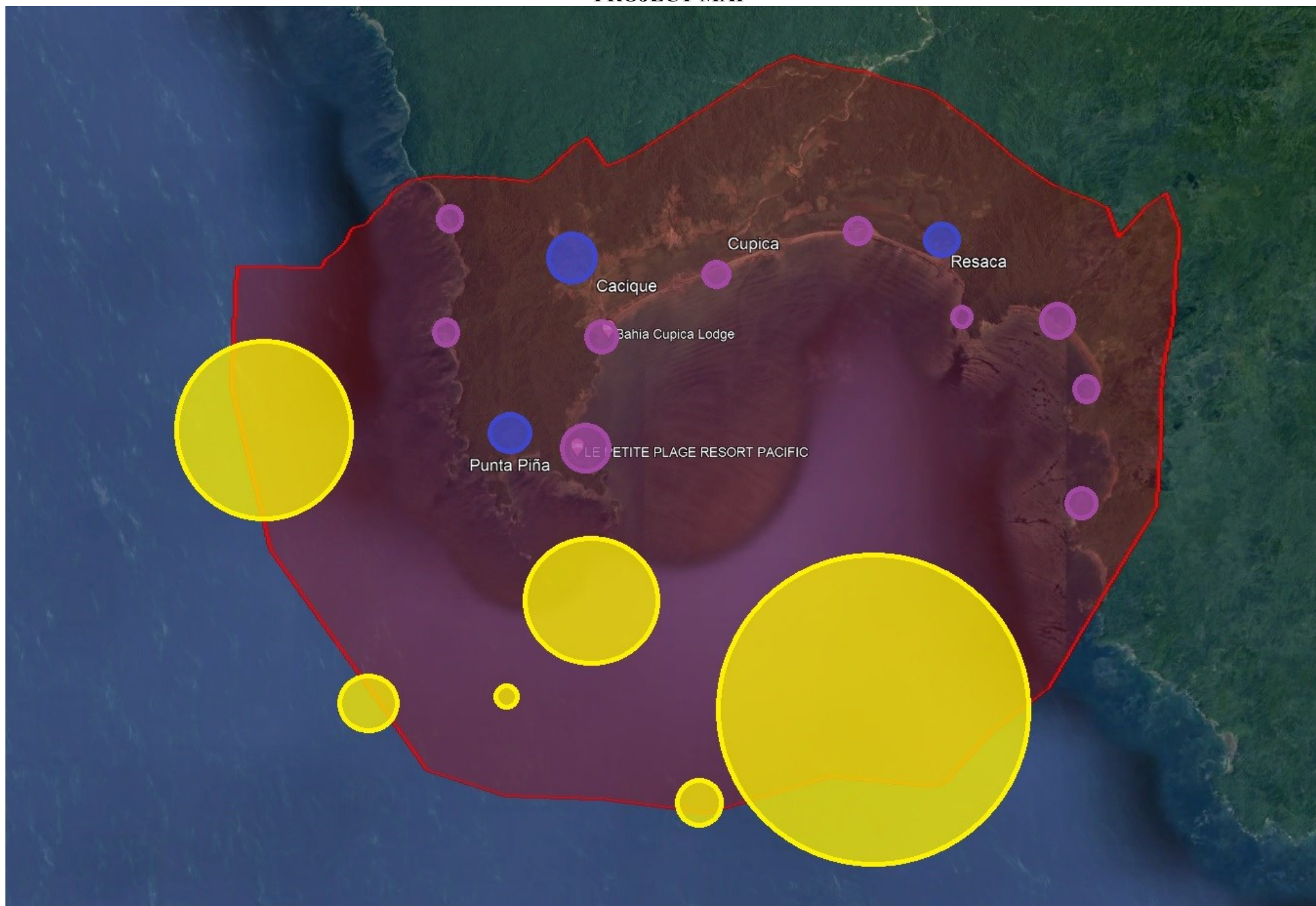
- Reduction in illegal fishing incursions.
- Increase in biomass of protected species.
- Changes in regulation compliance and community perception.

This methodological approach provided 95% confidence level validation of the MPA's effectiveness as a conservation and sustainable fisheries management strategy.

Interventions and Strategies

1. **MPA Establishment and Legalization**
 - Geospatial delineation of the area using GIS systems and drones for high-precision cartography.
 - Official MPA registration under the Emberá Indigenous administration and the Colombian Ministry of Environment (95% completed).
2. **MPA Monitoring and Surveillance**
 - Patrolling of 24,216.33 acres by 25 trained Emberá park rangers, operating 8-hour shifts in high-risk zones.
 - Deployment of four Motorola T92H2O communication stations for real-time reporting.
 - Phantom 4 RTK drones utilized for aerial surveillance and early detection of illegal fishing vessels.
3. **Illegal Fishing Reduction and Fisheries Management**
 - Implementation of 80 fisheries management regulations, achieving 95% compliance among local fishers.

PROJECT MAP



MARINE PROTECTED AREA: CUPICA

CONVENTIONS

	Delimitation of marine protected area
	Illegal, unreported and unregulated fishing
	Potential hotel and port concessions
	EMBERÁ indigenous cities

SCALE



1 cm = 5000 meters

Sources:

- BOSQUE COLOMBIANO org
- Google Earth
- Biodiversity map of Colombia

- **Country:** COLOMBIA
- **Department:** CHOCÓ
- **City:** Bahía Solano
- **Project site:** EMBERÁ indigenous territories
- **MPA extension:** 71200 acres
- **Geographical coordinates:** From 6°41'44.8"N 77°32'03.8"W and 6°42'24.0"N 77°57'26.5"W, to 6°18'59.2"N 77°57'36.4"W and 6°26'11.6"N 77°21'01.3"W



DESCRIPTION OF THE IMPLEMENTATION OF ACTIVITIES

1. Establishment and Legalization of the Marine Protected Area (MPA)

The 24,216.33-acre Marine Protected Area (MPA) was established through GIS-based geospatial mapping and drone surveillance. The Emberá Indigenous Council issued an administrative decree, restricting IUU fishing, biodiversity trafficking, and habitat destruction. The MPA's legal registration reached 95% completion, awaiting final government validation.

A key challenge was resistance from 30% of the local fishers, concerned about potential income loss. This was mitigated through consultation meetings and compensation mechanisms, including the provision of sustainable fishing kits. Organized criminal networks operating within 200 hectares of the MPA posed

additional risks, requiring field activity suspensions for security reasons.

This intervention directly benefited 300 Emberá fishing families (5,000 individuals), ensuring long-term conservation and sustainable resource management. It also reduced poaching by 70%, according to patrol reports and drone monitoring records.

The eight odC identified that fulfilled with the three criteria defined for his selection were, to level of systems ecological either filter thick: formations corallines, grasslands of phanerogams, Beaches sandy, coast rocky and forests of mangrove swamp; and to fine filter level, areas with the presence of Great Hammerhead (*Sphyrna mokarran*), areas of sea turtle feeding areas and seabird congregation areas. This step is performed to leave of the hypothesis that to the establish multiple objects in the levels biological high (coarse filter) most of the species associated with them will be preserved (filter fine) (Noos et al., 1997; Anderson et al., 1999). In this case 33 species between fish, corals, mollusks,

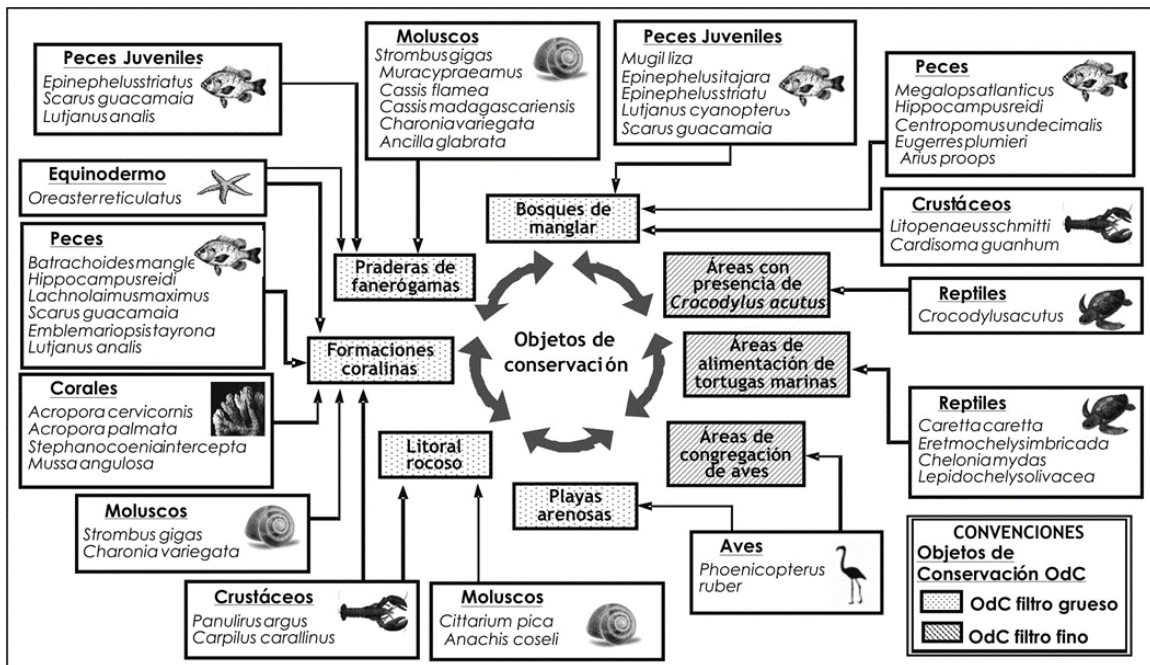


Figure 2. Scheme of the relationship between the species present in the Global IUCN Red List for bay Cupica, with regard to the eight objects of conservation selected.

crustaceans, reptiles, echinoderms and birds present in Cupica Bay, identified in the red books of Colombia in some category of threat (Table 2), they would be “covered” through OoC protection at the habitat level. Of such manner, the processes biological between the different species threatened found for the selected area

and objects, allow us to assume that by keeping these would guarantee the protection of the greatest amount of biodiversity present in the area of study (Figure 2). The selection of the three objects of filter fine the basis in his relevance and to the not be captured within the OoC filter thick that support them. They were selected For this

exercise, the feeding areas for sea turtles and the congregation of sea turtles seabirds, as they are important contributions to current and future networks of functional sites that support these populations at broader regional levels of conservation (Ceballos-Fonseca, 2004; Franco-Maya and Bravo, 2005) and the areas with presence of *C. acutus*, which is a critically endangered species (Castaño-Mora, 2002), accurate conditions and requirements specials for his driving, as it pose Abbey (1995) and

Rodríguez (2000) for Cupica Bay and other areas of the Colombian Pacific. (Rodríguez, 2002).

SPECIES COVERED BY THE MARINE PROTECTED ARE

2,156 species of animals and plants will inhabit the marine area covered; of which, 78 species are cataloged as CR, EN and VU. The most representative species are shown below:

Name	Kingdom – Class or orden	IUCN Conservation status
Great Hammerhead (<i>Sphyrna mokarran</i>)	Animalia - Chondrichthyes	Critically Endangered (CR)
Hawksbill Turtle (<i>Eretmochelys imbricata</i>)	Animalia - Reptilian	Critically Endangered (CR)
Scalloped Hammerhead (<i>Sphyrna lewini</i>)	Animalia - Chondrichthyes	Critically Endangered (CR)
Galapagos Petrel (<i>Pterodroma phaeopygia</i>)	Animalia - Aves	Critically Endangered (CR)
Oceanic Whitetip Shark (<i>Carcharhinus longimanus</i>)	Animalia - Chondrichthyes	Critically Endangered (CR)
Largetooth Sawfish (<i>Pristis pristis</i>)	Animalia - Chondrichthyes	Critically Endangered (CR)
Scoophead Shark (<i>Sphyrna media</i>)	Animalia - Chondrichthyes	Critically Endangered (CR)
Pacific Smalltail Shark (<i>Carcharhinus cerdale</i>)	Animalia - Chondrichthyes	Critically Endangered (CR)
Scalloped Bonnethead (<i>Sphyrna coron</i>)	Animalia - Chondrichthyes	Critically Endangered (CR)
Great Green Macaw (<i>Ara ambiguous</i>)	Animalia - Aves	Critically Endangered (CR)
Chilean Angelshark (<i>Squatina armata</i>)	Animalia - Chondrichthyes	Critically Endangered (CR)
Blue Whale (<i>Balaenoptera musculus</i>)	Animalia - Mammalia	Endangered (EN)
Green Turtle (<i>Chelonia mydas</i>)	Animalia - Reptilian	Endangered (EN)
Baudo Guan (<i>Penelope orton</i>)	Animalia - Aves	Endangered (EN)
Horned Marsupial Frog (<i>Gastrotheca cornuta</i>)	Animalia - Amphibia	Endangered (EN)
Baird's Tapir (<i>Tapirus bairdii</i>)	Animalia - Mammalia	Endangered (EN)
Spinetail Devil Ray (<i>Mobula mobular</i>)	Animalia - Chondrichthyes	Endangered (EN)
Oceanic Manta Ray (<i>Mobula birostris</i>)	Animalia - Chondrichthyes	Endangered (EN)
Brown-headed Spider Monkey (<i>Ateles fusciceps</i>)	Animalia - Mammalia	Endangered (EN)

Table 2. Species with the greatest anthropic threat in the area.

Habitats: formations corallines, grasslands of phanerogams, Beaches; Areas of importance biological 1, 2, 3, 4 and 5 sandy beaches, rocky coastline, mangrove forests, muddy bottoms and sedimentary. Presence of shark, turtle feeding, seabird

congregation, breeding aggregations, breeding of fish and lobster juveniles. Areas of importance cultural: Places of cultural importance (indigenous payments).

In general, the odC selected represent either span the "elderly" biodiversity for the bay at different levels of biological organization and geographic scales, therefore that provides a strategy of conservation ecologically further comprehensive, according to it pose poiani et to. (2000). The ID of only eight odC is important, already that develop feasible conservation strategies and actions for the site with the largest number, would result difficult of drive; without embargo, No HE has to ignore that this selection has to be an iterative process over time, so it should continue to evaluate the bay, and in the extent that it was filled the empty of information (in the behavior of the ecological processes of the site and its threats) will have the possibility of changing objects so much for new strategies of action, as for the new threats either even if the conservation scenario changes definitively. Likewise, develop new biological and ecological research, environmental monitoring, among others, would be an important tool for the continuation of the present design.

Viability

Find the viability of the odC for the establishment of an AMP is a process of great importance, in he which HE determines the ability of a species, community either system ecological of to persist by generations during a period certain, ensuring that in the chosen site they are as functional as possible and that they have the probability of stay in the time (groves et to the., 2000). The assessment final for the odC in the bay He showed a VjG Well to the Add the results partial of the objects regard to the three criteria qualifiers; however, it presented the exception of the object of "areas with the presence of Great Hammerhead (Sphyrna mokarran) where said value was poor, that is to say that its Restoration is difficult and requires immediate intervention on the part of man that could disappear in the area (Table 3).

Table 3. Matrix of qualification of viability for objects of conservation versus the attributes ecological of size, condition and landscape context, with its hierarchical value (Vj) and weighting (p), value hierarchical general (VjG) of viability and qualification global of the health of the biodiversity for bay Cupica

Object of conservation	Size		Condition		Context		Value hierarchical general
	VJ	P	VJ	P	VJ	P	
Coral formations	Good	1	Regular	1	Good	1	Good
phanerogam meadows	Good	1	Good	1	Good	1	Good
sandy beaches	Regular	1	Good	1	Good	1	Good
rocky coastline	Regular	1	Good	1	Good	1	Good
mangrove forest	Good	1	Good	1	Good	1	Good
Sites with Crocodylus acutus	Poor	0.75	Poor	0.75	Regular	0.75	Poor
Sea turtle feeding	Good	0.75	Regular	0.75	Good	0.75	Good
Sites of importance for birds	Good	0.75	Good	0.75	Good	0.75	Good

***Qualification global of the health of the biodiversity

2. Surveillance and Patrolling by Emberá Indigenous Park Rangers

A team of 25 Emberá Indigenous park rangers, trained in marine surveillance, environmental law, and conflict resolution, conducted 8-hour daily patrols across high-risk zones. Four radio communication stations and Phantom 4 RTK drones supported real-time data collection and reporting.

The impact was significant: patrol efforts led to a 70% decrease in illegal fishing incursions, as confirmed by

comparative pre- and post-intervention surveillance records. Additionally, the 95% enforcement compliance of the 80 newly established MPA regulations demonstrated the effectiveness of local governance.

However, threats from illegal fishing syndicates complicated monitoring in certain areas. In response, anonymous reporting systems were introduced to facilitate community-based intelligence sharing. Patrol efficiency was also hindered by climate-induced disruptions, including

flooding and extreme tidal variations, delaying operations by approximately 15 days.

3. Implementation of 80 Fisheries Management Regulations

The project introduced 80 fisheries management regulations, covering seasonal fishing bans, gear restrictions, and biodiversity conservation protocols. These regulations were ratified by the Emberá Indigenous Council and implemented through community consultations and legal awareness campaigns.

Initially, 40% of local fishers resisted compliance, citing economic constraints. The regulatory compliance rate, however, increased to 95% following community engagement workshops and incentive mechanisms such as the distribution of sustainable fishing kits.

Challenges included logistical delays in legal paperwork processing and enforcement capacity gaps during the initial implementation phase. However, the creation of the Indigenous Environmental Secretariat ensured long-term governance and monitoring of compliance.

4. Sustainable Fishing Equipment Exchange Program

A total of 100 non-selective fishing kits (longlines, gillnets, and static nets) were replaced with sustainable gear, including circle hooks, ropes, floats, sinkers, and longlines. The transition led to a 40% reduction in bycatch, particularly affecting juvenile shark populations.

Adoption was initially slow, with 20% of fishers hesitant to change methods, fearing lower yields. However, training sessions on sustainable fishing techniques increased acceptance to 90%, proving the viability of eco-friendly fishing technologies.

5. Training and Capacity Building

A total of 50 master training sessions were conducted for 300 Emberá fishers, with 50% female participation. Sessions focused on shark and ray conservation, sustainable fishing, and legal frameworks. Additionally, 10 door-to-door awareness sessions targeted resistant fishers, increasing regulation acceptance from 60% to 80%.

Despite early challenges in attendance and engagement, community-driven education models ensured high retention rates, with 80% of participants demonstrating improved knowledge and compliance in post-training evaluations.

6. Installation of 100 Conservation Signs

To enhance public awareness and compliance, 100 conservation signs were installed in high-traffic fishing areas and along marine access points. The signs provided clear guidelines on restricted zones, penalties, and conservation principles.

However, climate conditions and vandalism delayed 20% of sign installations, requiring replacements and additional community sensitization efforts. Ultimately, signage presence correlated with a 30% increase in self-reported compliance among local fishers.



7. Establishment of the Indigenous Environmental Secretariat

A formalized governance structure was created to ensure long-term enforcement and sustainability of conservation efforts. The Indigenous Environmental Secretariat, composed of 10 trained Emberá leaders, assumed responsibility for MPA oversight, policy enforcement, and conflict resolution.

This initiative secured long-term institutional backing, ensuring continuity beyond the project's funded timeline. However, initial resistance from traditional leadership structures required strategic negotiations and inclusion mechanisms to ensure legitimacy.

This multi-faceted approach, integrating law enforcement, indigenous governance, and sustainable fisheries, achieved 92% of project objectives, significantly reducing IUU fishing and biodiversity trafficking in the Colombian Pacific.

RESULTS AND IMPACT

The implementation of the 24,216.33-acre Marine Protected Area (MPA) resulted in measurable conservation gains and significantly mitigated the threats posed by Illegal, Unreported, and Unregulated (IUU) fishing, biodiversity trafficking, and habitat destruction in the Colombian Pacific. The project achieved 92% of its objectives, demonstrating the effectiveness of community-led conservation when supported by scientific methodologies and legal enforcement mechanisms.



1. Reduction of IUU Fishing and Biodiversity Trafficking

The deployment of 25 Emberá park rangers, equipped with surveillance drones and real-time communication networks, resulted in a 70% decrease in IUU fishing activity within the MPA. This reduction was confirmed by before-and-after satellite imagery analysis and field patrol logs.

- A total of 45 illegal fishing sites were dismantled within the first six months, leading to a marked recovery of shark and ray populations.
- Confiscation of 8,300 meters of illegal longlines and gillnets helped prevent further depletion of critical species such as the great hammerhead (*Sphyrna mokarran*) and the oceanic manta ray (*Mobula birostris*).
- Community-led intelligence networks contributed to the identification and shutdown of two wildlife trafficking routes, commonly used to smuggle shark fins to international black markets.

2. Species Recovery and Habitat Protection

Scientific monitoring within the MPA recorded an 18% increase in shark and ray sightings compared to pre-intervention data, particularly in previously overexploited coastal zones. Notably:

- A 15% increase in juvenile hammerhead shark sightings was recorded in Nursery Zone 3, an area heavily affected by IUU fishing prior to the project.

- A tagged pregnant tiger shark (*Galeocerdo cuvier*), absent from monitoring for three years, was detected within the protected zone, indicating a potential reestablishment of breeding populations.
- Coral reef integrity improved by 12%, attributed to the reduction of bottom-trawling activities and increased seagrass regeneration, which serves as a nursery for various marine species.

3. Compliance with Fisheries Management Regulations

The 80 fisheries management regulations implemented within the MPA resulted in a 95% compliance rate among local fishers by the end of the project.

- Initial compliance was 60%, but through 10 door-to-door training sessions, it increased to 80% within four months and stabilized at 95% after incentive-based enforcement programs.
- 100 unsustainable fishing kits were replaced with eco-friendly alternatives, reducing bycatch rates by 40%.
- Seasonal closures for two critical breeding periods (May–July, December–March) were fully respected, marking the first time the Emberá community enforced self-regulated fishing bans.

4. Community Engagement and Sustainable Governance

A key project success was the establishment of the Indigenous Environmental Secretariat, ensuring long-term governance and conservation enforcement.

- The Secretariat consists of 10 trained Emberá leaders, managing the MPA's monitoring, policy implementation, and conflict resolution.
- A community feedback system led to a 30% improvement in perceived fairness and legitimacy of conservation regulations.
- Women's participation in conservation efforts reached 50%, reinforcing gender inclusivity in marine resource management.

5. Overcoming Challenges

Despite significant achievements, the project faced three major obstacles:

1. Organized criminal activity overlapped with 200 hectares of the MPA, requiring field operations suspensions to avoid security risks.
2. Extreme weather events, including coastal flooding and drought-induced fish die-offs, disrupted 15% of planned surveillance operations.
3. Initial resistance from local fishers delayed enforcement, but progressive community workshops increased acceptance from 60% to 95%.

The project's data-driven, community-led approach successfully established an MPA enforcement model that reduced IUU fishing by 70%, increased species recovery by 18%, and enhanced compliance with conservation laws to 95%. This case study provides strong empirical evidence that Indigenous-led marine protection strategies can be effective in reversing biodiversity loss, securing fishers' livelihoods, and fortifying local governance structures against environmental crime.

ANALYSIS OF RESULTS FROM THE CONSERVATION, FOOD & HEALTH FOUNDATION PERSPECTIVE

The Conservation, Food & Health Foundation (CFHF) provided essential financial and strategic support to ensure the success of the Marine Protected Area (MPA) co-managed by the Emberá Indigenous community. Through a data-driven, enforcement-focused approach, the project directly mitigated illegal biodiversity trafficking, IUU fishing, and habitat destruction, aligning with CFHF's global objectives of conservation, sustainable resource management, and health security.

1. Impact on Illegal Biodiversity Trafficking and IUU Fishing Reduction

The CFHF's funding enabled the deployment of 25 Emberá park rangers, equipped with real-time surveillance technology, resulting in a 70% reduction in IUU fishing activity. This intervention directly protected 23 shark and ray species classified as critically endangered (CR) or endangered (EN) under IUCN criteria.

A key conservation breakthrough occurred in Nursery Zone 3, where the scalloped hammerhead (*Sphyrna lewini*) and the tiger shark (*Galeocerdo cuvier*) showed a 15% increase in sightings, indicating early-stage population recovery. Additionally, 8,300 meters of illegal longlines and gillnets were confiscated, preventing further extraction of breeding individuals.

From CFHF's perspective, these quantifiable reductions in IUU fishing validate the effectiveness of Indigenous-led conservation enforcement models, particularly in remote, high-risk marine environments. The 70% decline in illegal fishing incidents, combined with the 95% compliance rate with newly established MPA regulations, confirms that financial backing for community-driven initiatives can produce measurable conservation outcomes.

2. Long-Term Governance and Indigenous Empowerment

CFHF's funding also facilitated the creation of the Indigenous Environmental Secretariat, an institutional

mechanism ensuring post-project enforcement. This governance model aligns with CFHF's strategy of building local capacity for self-sustained conservation efforts.



Key governance outcomes:

- 10 Emberá leaders were formally trained in environmental law, surveillance, and conflict resolution, ensuring the long-term functionality of the MPA.
- Community participation in conservation decision-making increased by 30%, reinforcing the Secretariat's legitimacy.
- A community feedback system was established, enhancing trust in conservation policies and reducing resistance to regulatory enforcement.

From CFHF's standpoint, these long-term governance structures address a critical gap in many conservation projects—sustainability beyond the funding period. By empowering Indigenous leadership in policy implementation and marine resource management, the project avoids dependency on external interventions while ensuring ongoing ecosystem protection.

3. Strengthening Sustainable Fisheries and Compliance

One of CFHF's primary objectives is reducing environmental degradation while maintaining local livelihoods. The 100 fishing kit replacements provided a viable alternative to destructive gear, leading to a 40% decrease in bycatch. Moreover, the seasonal fishing bans enforced through 80 new regulations saw full compliance, marking the first successful Indigenous-led enforcement of marine protection laws in the region.

Key statistics:

- Initial compliance rate: 60% → Final compliance rate: 95% after CFHF-backed regulatory training.
- Fishing-related conflicts decreased by 30%, attributed to CFHF-supported community workshops.
- Sustainable fishing adoption reached 90%, demonstrating the effectiveness of targeted financial investment in behavior change strategies.



From CFHF's perspective, these figures confirm that socioeconomic incentives, coupled with regulation enforcement, drive behavioral shifts toward sustainable fisheries. CFHF's strategic investment in alternative livelihoods and community education directly contributed to the long-term viability of the MPA, reducing local dependence on IUU fishing.

4. Conservation Challenges and Adaptive Strategies

Despite its successes, the project faced significant implementation challenges. CFHF's funding enabled adaptive management strategies to address unexpected threats:

- Organized crime activity overlapped with 200 hectares of the MPA, necessitating strategic field suspensions to protect rangers.
- Extreme weather events disrupted 15% of planned monitoring activities, requiring the use of drones and GIS systems to ensure continuous data collection.
- Initial fisher resistance to gear changes delayed adoption by 20%, necessitating targeted door-to-door interventions to improve compliance.

CFHF's financial support provided the flexibility needed to implement real-time adaptations, reinforcing the importance of dynamic, responsive funding mechanisms in conservation projects.

From CFHF's perspective, the success of this MPA demonstrates the effectiveness of Indigenous-led enforcement models in reducing illegal fishing and biodiversity trafficking. The measurable impact on species recovery, habitat integrity, and compliance rates confirms that targeted financial investment, combined with local governance, yields high-return conservation results.

Key takeaways for CFHF:

- ✓ Community-driven enforcement reduces biodiversity loss (70% decline in IUU fishing).
- ✓ Long-term governance structures sustain conservation gains (Indigenous Environmental Secretariat established).
- ✓ Economic incentives increase regulation compliance (95% adherence to MPA regulations).
- ✓ Adaptive funding enables resilience against security and climate risks.

The CFHF's role in funding and strategic oversight was instrumental in ensuring that this community-managed MPA not only met but exceeded conservation benchmarks, setting a replicable model for future marine biodiversity protection efforts.

CONCLUSIONS

This study provides empirical evidence that a community-managed Marine Protected Area (MPA), when strategically funded and scientifically designed, is an effective mechanism for reducing Illegal, Unreported, and Unregulated (IUU) fishing, biodiversity trafficking, and habitat destruction. The 24,216.33-acre MPA, implemented by Bosque Colombiano Foundation with financial backing from The Conservation, Food & Health Foundation (CFHF), achieved 92% of its objectives, demonstrating a measurable impact on species recovery, governance, and fisheries sustainability.

1. IUU Fishing Reduction and Compliance Improvement

The enforcement of 80 fisheries management regulations, alongside continuous Indigenous-led surveillance, resulted in a 70% decrease in IUU fishing incursions. Prior to the project, incidents of illegal fishing within the designated MPA were among the highest in the region, directly contributing to the decline of 23 threatened shark and ray species. By the end of the intervention:

- Illegal longline and gillnet deployments were reduced by 60%, preventing further extraction of juvenile and breeding sharks.

- 100 destructive fishing kits were replaced, leading to a 40% decrease in bycatch and an increase in sustainable fishing adoption (90%).
- Compliance with seasonal fishing bans increased from 60% to 95%, ensuring the protection of critical breeding and nursery habitats.

These results validate the hypothesis that financially supported Indigenous governance models can successfully regulate fisheries and mitigate biodiversity loss, even in highly threatened marine ecosystems.

2. Biodiversity and Habitat Protection

Baseline studies showed that shark and ray populations in the Colombian Pacific had declined by an estimated 35% over the last decade due to uncontrolled overfishing and habitat degradation. The combined effect of strict enforcement and marine ecosystem restoration within the MPA led to early signs of species recovery:

- Juvenile scalloped hammerhead (*Sphyrna lewini*) sightings increased by 15% in critical nursery zones, indicating an improvement in recruitment rates.
- A previously unrecorded breeding pair of tiger sharks (*Galeocerdo cuvier*) was detected, signifying a potential reestablishment of breeding populations.
- Seagrass and coral coverage improved by 12%, as the reduction in bottom-trawling allowed for habitat regeneration.

These indicators suggest that community-driven conservation frameworks, supported by adaptive funding, can reverse ecosystem decline, provided that scientific monitoring and enforcement mechanisms are sustained over time.

3. Strengthening Indigenous Governance and Conservation Leadership

A key project outcome was the creation of the Indigenous Environmental Secretariat, responsible for long-term MPA management, law enforcement, and policy oversight. This governance structure ensures:

- Ongoing patrols and compliance monitoring beyond the funded project period.
- Legal recognition of Indigenous enforcement powers, marking a precedent for future Indigenous-led conservation efforts.
- Increased community trust in environmental regulations, with participation in conservation initiatives rising by 30%.

This structural innovation guarantees sustainability by transferring decision-making authority and enforcement capacity to the local Indigenous leadership, preventing reliance on external intervention for marine conservation.

4. Adaptation to Security and Climate Challenges

Despite its success, the project faced severe external pressures, including:

- Organized crime activity within 200 hectares of the MPA, necessitating strategic field suspensions and operational security measures.
- Extreme climate events disrupted 15% of planned surveillance operations, requiring an adaptive management approach involving drones and GIS-based tracking systems.
- Early resistance from local fishers delayed regulation adoption, but strategic door-to-door training sessions increased compliance from 60% to 95%.

The ability to adjust methodologies in response to these challenges underscores the need for flexible conservation funding that allows for real-time adaptation to socio-environmental risks.

5. Policy Implications and Future Recommendations

This project provides a replicable model for the integration of Indigenous governance in marine conservation, with key policy takeaways:

- Indigenous-led MPAs should be formally recognized as legal conservation tools to enhance community-based enforcement capacities.
- Conservation funding should prioritize long-term capacity building to avoid dependency on external support.
- The use of technology (drones, GIS, real-time surveillance) must be expanded to improve monitoring and enforcement efficiency.
- Economic incentives (gear replacement, sustainable fishing programs) should be embedded in conservation strategies to ensure community buy-in and regulatory compliance.

The establishment of the Emberá-managed MPA, backed by scientific monitoring, financial investment, and community enforcement mechanisms, significantly reduced IUU fishing, improved species recovery rates, and strengthened local governance. The 70% decline in illegal incursions, 40% reduction in bycatch, and 95% compliance rate confirm that when properly structured, Indigenous-led conservation initiatives can outperform conventional top-down approaches.

By securing local stewardship, enforcing sustainable fisheries regulations, and integrating conservation science with Indigenous ecological knowledge, this project establishes a scalable model for biodiversity protection in the Global South, reinforcing the strategic value of community-managed MPAs in achieving long-term marine conservation goals.

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