Aruba Conservation Foundation

Natural Values and Anthropogenic Impacts on Reef Islands of Aruba

With a Focus on Impacts of Recreational Development and Operation

July 2025

Executive Summary

The reef islands of Aruba, locally known as “rif” or “cay,” are ecologically vital components of the island’s coastal and marine environment. These low-lying landforms, along with associated mangrove forests, seagrass meadows, and coral reefs—collectively referred to as the “Power of Three”—support exceptional biodiversity, provide critical ecosystem services, and underpin Aruba’s cultural traditions and tourism-driven economy.

Natural Values

- Aruba’s reef islands host over 240 documented species, including protected and endangered marine life such as sea turtles, Queen Conch, and Caribbean Spiny Lobster.
- These ecosystems offer essential services: coastal protection, water filtration, carbon sequestration, nutrient cycling, and nursery habitats for commercially and ecologically important species.
- The interconnectedness of mangroves, seagrasses, and coral reefs enhances ecosystem resilience and biodiversity.

Anthropogenic Impacts

- Rapid and unregulated recreational development—including illegal construction of ranchos, piers, and artificial beaches—has led to habitat loss, fragmentation, pollution, and water quality degradation.
- Direct impacts include mangrove removal, sedimentation from beach construction, and sewage discharge into the marine ecosystems.
- Indirect effects such as eutrophication, trash, wildlife disturbance, and illegal harvesting of protected species further threaten ecosystem integrity.
- These cumulative pressures are pushing Aruba’s reef islands’ ecosystems toward a critical ecological tipping point, negatively impacting biodiversity.

Conservation and Management

- Aruba’s reef islands are protected under national legislation and international agreements (e.g. Nature Protection Ordinance, Ramsar Convention, SPAW Protocol).
- The Aruba Conservation Foundation (ACF) manages these areas through a suite of conservation frameworks and management plans.
- A science-based Integrated Coastal Zone Management (ICZM) approach is recommended, emphasizing:
    - Baseline biodiversity assessments and habitat mapping
    - Carrying capacity evaluations
    - Enforceable zoning and regulatory frameworks
    - Nature-Based Solutions (NbS) for ecosystem restoration
    - Cross-sectoral collaboration among stakeholders

To safeguard the ecological and socio-economic value of Aruba’s reef islands, urgent action is needed to halt unsustainable development and implement integrated, science-driven and evidence-based conservation strategies. By aligning cultural traditions, tourism and development with ecological stewardship, Aruba can serve as a model for sustainable island management in the Caribbean.

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1. Introduction

Aruba is a small island nation situated in the Southern Caribbean, approximately 25 kilometers north of the coast of Venezuela. Geographically part of the Leeward Antilles, Aruba lies outside the Atlantic hurricane belt and features a semi-arid climate with sparse rainfall and consistent trade winds. Its landscapes range from dry cactus-studded scrublands and limestone plateaus to rugged coastlines, white sandy beaches and shallow marine environments. Ecologically, Aruba's position along the southern edge of the Caribbean Sea supports a diverse range of coastal and marine habitats, including coral reefs, mangroves, seagrass beds, and reef islands. Despite its limited land area, Aruba harbors a range of endemic and regionally significant species, making it an important ecological hotspot within the Southern Caribbean.

Coastal reef islands, locally known as 'rif' or 'cay', are critical components of Aruba's nearshore marine ecosystem. These small, low-lying landforms, formed by the accumulation of coral rubble and sand on reef structures, provide essential nesting and roosting sites for seabirds and the occasional sea turtle, while also supporting coastal vegetation and acting as steppingstones for biodiversity. Being such hotspots for biodiversity, fisheries benefit from the nursery and feeding grounds of these fringing reef islands. Many commercially significant species such as Snappers and Groupers depend on the ecosystems these reef islands sustain.

The reef islands and mangrove areas (**Error! Reference source not found.**) along the southern coastline of Aruba are unique characteristics of the island. By National Decree (AB 2020 no. 67) under the Nature Protection Ordinance (Natuurbeschermingsverordening, AB 1995 no. 2), these reef islands are designated protected nature areas. The Aruba Conservation Foundation (ACF), an independent conservation management organization, is encharged with the management of all protected nature areas, including marine protected areas (MPAs) and Aruba's fringing coastal reef islands.

Image 1: Protected Nature Areas of Reef Islands and Mangroves managed by ACF.

Traditionally, the reef islands are used by the local community for recreation, including swimming, snorkeling, passing the day and camping, where families would construct small-scale shelters called 'ranchos' (recreational 'beach' huts) made of wood and roofing scraps. To facilitate access by boat, many of these ranchos are accompanied by pier construction extending into the coastal lagoon on the mainland side of the reef island. What once was a cultural tradition has reached a new scale of visitation with increasing economic interests as the different reef islands are becoming popular amongst tour operators, serving as popular tourism attractions for snorkeling, diving, and boat excursions, which collectively contribute to local livelihoods.

However, growing recreational development— including the construction and expansion of illegal ranchos and piers, and unregulated visitor access—poses increasing pressure on these fragile coastal and marine ecosystems, highlighting the urgent need for integrated conservation and management

strategies. With the increasing pressures from development of these islands, this report aims to illustrate the ecological significance, biodiversity and natural values, and (potential) anthropogenic threats associated with such development within protected areas, as a basis for policy regarding the 'Ranchos' and sustainable recreation on Aruba's legally protected reef islands.

2. Natural Values of Aruba's Reef Island Ecosystems

2.1 Key Habitats

The reef islands of Aruba are of unique ecological value and host the majority - if not all - species that are part of Aruba's coastal and marine biodiversity. For many species these reef islands, and their unique composition and geographic location on the leeward side of Aruba, play an essential role in one or more phases of their life cycles.

The "Power of Three"

Aruba's coast harbors mangrove forests, seagrasses, and coral reefs. These crucial ecosystems are naturally interconnected and provide a variety of benefits to humans and the environment:

Mangrove forests

Mangroves are woody trees that flourish on the land-sea interface. These plants are highly adapted to survive in these waterlogged, anoxic sediments and salty conditions that would be fatal to most other flora. Mangrove forests prevent coastal and reef island erosion, absorb nutrients, sequester carbon dioxide from the air, filter run-off from land, and provide a nursery and feeding habitat to numerous species of birds, fish and crustaceans. Mangrove aggregations represent one of the most valuable coastal/marine ecosystems in the world, with high productivity and high associated biodiversity.

. At the reef islands, the mangroves protect the reef islands fragile coastline and form channels that host a myriad of species and have a nursery function for ecologically significant species such as Rainbow Parrotfish (*Scarus guacamaia*) and Lemon Sharks (*Negaprion brevirostris*), and commercially important species such as Snappers (Lutjaninae) and Great Barracuda (*Sphyraena barracuda*) (Image 2).

Image 2: A juvenile Great Barracuda (Sphyraena barracuda) in reef island lagoon mangrove and seagrass area (ACF, 14 July 2025).

All species of mangroves found in Aruba are protected by national decree under the Nature Ordinance (AB 1995 no2, Article 4, 1a & 2a).

Seagrass meadows

Seagrasses are marine flowering plants that live underwater. Like land plants, seagrasses produce oxygen. Seagrass beds form in shallow coastal lagoon areas as they require high light availability. Seagrass ecosystems are among the most productive in the world.

The leaves of seagrasses provide a huge surface area for settlement of epiphytes (plants that live on the surface of another organism such as calcareous green algae, crustose coralline red algae, cyanobacteria, diatoms) and epifauna (animals that live on the surface of another organism such as sponges, hydroids, bryozoans, and foraminifera's). For a square meter of seabed, a dense seagrass stand may have $20m^2$ of leaf area for other organisms to settle on. The productivity of the epiphytes can be twice that of the seagrasses themselves. Through a succession of growth, seagrasses turn vast areas of unconsolidated sediments into a highly productive plant dominated, structured habitat with a diversity of microhabitats.

Moreover, seagrass meadows bind sediments, sequester carbon, absorb nutrients, and support a diverse range of vertebrate and invertebrate communities. This includes ecologically important Parrotfish (*Scaridae*) and Goatfishes (*Mullidae*), as well as commercially important fish species such as Groupers (*Epinephelidae*) and Snappers (*Lutjaninae*).

All native species of seagrass are protected by national decree under the Nature Ordinance (AB 1995 no2, Article 4, 1a & 2a).

Coral reefs

Coral reefs protect the coastline from storms and erosion, are a source of livelihood and recreation, and have been called 'rainforests of the seas' for their high biodiversity. Corals are diverse groups of invertebrate animals that are related to jellyfish and sea anemones. Different species of coral are found in different habitats and different locations around the world. Stony corals like Acroporids, star corals and brain corals are reef-building corals. Colonial stony corals, consisting of hundreds to hundreds of thousands of individual polyps, are cemented together by the calcium carbonate "skeletons" they secrete. As colonies grow over hundreds and thousands of years, they join with other colonies and become reefs (Kaiser MJ, 2020).

Coral reefs teem with life. Although they cover less than one percent of the ocean floor, they support about 25 percent of all marine creatures. Corals are particularly vulnerable to the effects of human activities including pollution, climate change, sedimentation, trampling, and fishing. Over 100 species of soft corals and 60 species of stony coral occur in the Caribbean region, including the waters around Aruba, and of which 25 species are frequently encountered in Aruba (Vermeij, 2020). Under the Endangered Species Act, more than 25 coral species are listed as threatened or endangered.

All species of stony and soft corals are protected by national decree under the Nature Ordinance (AB 1995 no2, Article 4, 1b).

The health of these three ecosystems – mangrove, seagrass, and coral - are interconnected (Guannel, 2016). Therefore, when one of these ecosystems is damaged, it can have a severe negative impact on other ecosystems and their associated flora and fauna. For example, if mangroves are destroyed, it can lead to increased erosion and flooding which in turn damages the seagrass and coral reefs. All these sub-

ecosystems work together. If one is negatively affected, it could induce a negative feedback loop where all sub-ecosystems and their associated biodiversity are eventually affected.

Numerous marine species depend on the combined "Power of Three" - mangrove, seagrass, and coral reef - as they progress through these ecosystems during their different life stages from birth to adulthood and reproduction. An example of such interdependencies can be illustrated with the Grey Snapper (*Lutjanus griseus*) (Image 3), a species also observed at the reef islands of Aruba.

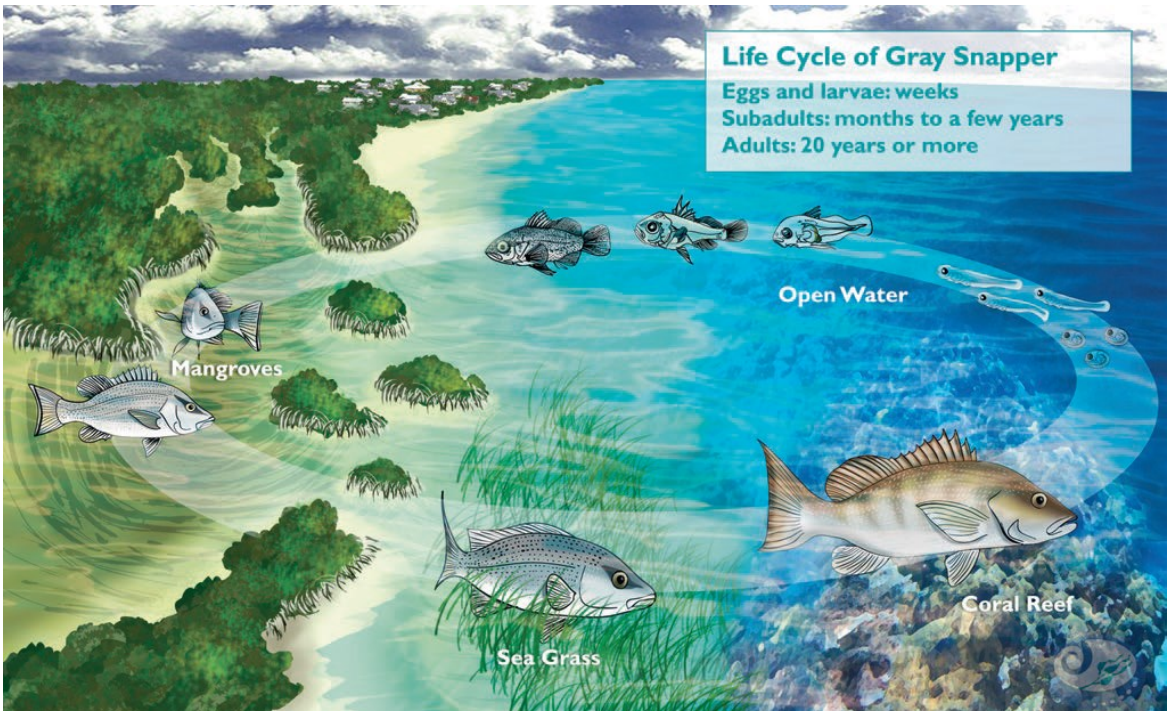

Image 3: The life cycle and interconnected ecosystem use by the Grey Snapper throughout its life phases (illustration form YOUMARES 8 Proceedings ***Invalid source specified.***

In Aruba, these crucial interconnected "Power of Three" systems are under severe threat from coastal development and other associated anthropogenic impacts (Debrot, 2018; Vermeij, 2020; Cullen-Unsworth L.C., 2014). These include but are not limited to coastal development, land-based sources of pollution, unregulated and unsustainable recreation, and extraction or harvesting. Therefore, what currently remains of mangroves, seagrasses and corals is already an absolute minimum of what ecosystems and biodiversity need to sustain Aruba.

2.2 Biodiversity

Reef islands are considered biodiversity hotspots as they host the "Power of Three" and all associated species. In the past decade, over 240 species have been documented on and around Aruba's reef islands and mangrove coastlines (**Appendix 1**).

Significant fauna observed include protected species such as Queen Conch (*Lobatus gigas*), Caribbean Spiney Lobster (*Panulirus argus*), Long-spined Sea Urchin (*Diadema antillarum*), at least 8 species of parrotfish (Scaridae), and 3 species of sea turtles.

2.3 Ecosystem Services

The ecosystems and biodiversity sustained by the reef islands form a connected coastal shield that enhances Aruba's resilience to climate change, supports livelihoods, and maintains marine biodiversity.

Coastal protection

Mangroves have dense root systems that dissipate wave energy and reduce storm surge impacts, protecting shorelines from erosion. Seagrass meadows stabilize the seabed with their roots and reduce wave energy, especially in shallow waters. Coral reefs act as natural breakwaters, absorbing the wave energy before it reaches the shore.

Water filtration

Mangroves trap sediments, heavy metals, and pollutants from land runoff, improving coastal water quality. Seagrass beds filter nutrients and trap fine sediments, enhancing water clarity. Coral reefs indirectly benefit from cleaner water provided by mangroves and seagrasses, which helps maintain coral health.

Nutrient cycling

Mangroves decompose organic matter and recycle nutrients through tidal flushing. Seagrass beds absorb nutrients like nitrogen and phosphorus, preventing eutrophication[1] which would negatively impact the different ecosystems and their associated biodiversity. Coral reefs host symbiotic relationships (e.g., with algae) that recycle nutrients efficiently in nutrient-poor waters.

Carbon sequestration and storage

Mangroves form among the most carbon-rich forests, storing carbon in both biomass and deep, waterlogged soils. Seagrass beds store carbon in sediments over long periods, contributing to 'blue carbon' sinks. Coral reefs, while not major carbon sinks, contribute to carbon cycling through calcium carbonate formation.

Nursery and feeding habitat

Mangroves provide shelter and food for juvenile fish, crustaceans, and birds. Seagrass beds serve as feeding grounds and nurseries for fish, sea turtles, and invertebrates. Coral reefs offer complex structures for shelter, serving as a breeding and feeding habitat for thousands of marine species.

Tourism recreation

Aruba's economy remains heavily reliant on its coastal and marine ecosystems, with tourism accounting for over 90% of the island's GDP in 2023, making it one of the most tourism-dependent economies globally. The economic contribution of nature-based tourism is estimated at approximately US$ 269 million annually, highlighting the vital role these ecosystems play in attracting visitors to the island. The government of Aruba recognizes the connection between a healthy environment and a thriving tourism sector, as coastal and marine ecosystems serve as primary attractions for visitors. However, like many other island nations, the relationship between the benefits provided by nature and sustainable development is not yet fully recognized and integrated into policymaking (Palacios, 2021).

[1] Harmful algal blooms, dead zones, and fish kills are the results of a process called eutrophication—which begins with the increased load of nutrients to estuaries and coastal waters (https://oceanservice.noaa.gov/facts/eutrophication.html).

3. Anthropogenic Impacts from Recreational Development and Operations

3.1 Types of Development on Aruba's reef islands and mangrove areas

Over decades, Aruba has developed its coastline to facilitate human access for enjoyment of the marine and coastal environment. Structures such as piers (Image 4), artificially enhanced beaches (Image 5) and ranchos (Image 66) have become a common sight along the coastlines. Each time a new structure is placed or expanded, nature is removed to make room for human-oriented infrastructure.

Image 4: Pier at a Rancho across from the Parkietenbos landfill.

Piers are used for boat landing and docking, fishing, and jumping in the refreshing sea. Ranchos provide shade and shelter from the Aruban sun and trade winds. Where historically families would build up these ranchos with minimal materials, mostly scraps from other construction works on land, the current ranchos are developed using dedicated materials and concrete structures, and some of the constructions now even include 2 floor levels.

Image 5: Artificially created and maintained beach

Besides the rancho constructions being taken to a more advanced level, near several ranchos, the visitors or operators are developing artificial beaches on top of or in place of coral rubble, corals, seagrass, mangroves, and lagoons.

With the expansion from traditional local family use to tourism exploitation the number of visitors frequenting these reef islands has increased over the past years, while many developers, operators and visitors may not be aware of the unique yet fragile ecosystems and biodiversity that these reef islands hold.

Image 6: Example of an over water Rancho.

3.2 Direct Ecological Impacts

Habitat loss and fragmentation

As the reef islands are naturally covered with mangroves, whose roots hold the coral rubble in place, these mangroves are removed to make room for the construction of sheltered spaces for human use (**Error! Reference source not found.**7).

Each rancho construction does not only take the space of what once was a dense mangrove forest, by both the construction and the visitor use passing across the reef island, through the mangroves, this fragments the mangrove areas into smaller patches of mangroves (Image 8). Besides reducing the overall number of mangroves and the surface area that they cover, this also severely reduces the quality of the mangrove forest as an ecosystem that if undisturbed and unfragmented would host very high biodiversity.

Image 7: Mangroves are cut to make space for construction

Image 8: Aerial view of the reef island with 'ranchos' across from the Parkietenbos landfill, extracted from Google Earth Pro on July 16 2025.

Habitat alterations and sedimentation

Image 9: Potential illegal construction of beach.

Besides constructing shelters and piers, some developers create artificial beaches to cover coral rubble. Image 9 illustrates such development of an artificial beach in process. Larger concrete blocks and cylinders are laid in an area that was first cleared of mangroves. By stabilizing the rubble with these larger blocks, it would now be covered with sand to resemble a beach. When supplied with sand, this sand subsequently enters into the marine environment causing sedimentation of seagrass and corals, which suffocates and kills the seagrass and corals present, leading to further habitat and biodiversity loss.

Pollution

While constructing and recreating on the islands, visitors often leave garbage and debris behind. This pollution impacts the reef island's natural values by further encroaching on the space for nature. It can also be a direct danger to biodiversity by covering and shading plants that need sunlight and space to grow, and entrapping animals that migrate over the reef islands or in the water. See below compiled Image 10 for several examples.

Image 10: Several examples of forms of pollution commonly observed on the reef islands

Water quality degradation

With many visits spanning numerous hours to entire days, visitors will most likely use sunscreens and insect repellent which contain chemicals that pollute the marine environment and harms biodiversity.

Additionally, visitors to the reef island produce sewage water. This sewage water is not caught in septic tanks to be collected and disposed of properly on the mainland. Instead, the sewage pipes from the toilets on the reef island directly dump into the surrounding sea (Image 11). This sewage water subsequently pollutes the sea with excess nutrients, chemical pollutants, and solid pollution such as toilet paper.

Image 11: Sewage pipe from Rancho dumping directly into the sea.

3.3 Indirect and Cumulative Impacts

Increased sedimentation and eutrophication

Excessive nutrients over time can lead to eutrophication or other forms of disturbance to the integrity of the marine environment and with that, its ecosystems and biodiversity. Additionally, human recreation and development-associated sedimentation will lead to further habitat loss, resulting in ecosystem degradation and biodiversity loss.

Disturbance to wildlife

The sheer presence of human beings on these islands already has an impact on nature as the presence (smell, sounds, movement) of humans causes stress to wildlife in their natural environment. Increased human activity, be it in frequency or number of visitors, will amount to increased disturbance of wildlife.

Whether intentional or unintentional, visitors often feed wildlife. People give food items intended for human consumption to wildlife, or leftover food items are left behind or not disposed of properly to ensure the wildlife cannot get to it. This supplementary feeding with human food sources does not provide wildlife with the nutrition that they need for a healthy life, and may even be harmful, while also taking away the ecological roles that wildlife plays as grazers and/or predators. Additionally, wildlife feeding often favors the more adaptive, domesticable and invasive species, like the house sparrow and rats, and may upset natural balances by populations explosions of seagulls and green iguanas.

As part of the traditional practices on these islands, many visitors catch wildlife for consumption. In many cases, this is not limited to abundant and resilient species. Many traces (Image 12) can be found of illegal poaching of endangered and protected Queen conch (*Lobatus gigas*). Additionally, the fact that

Image 12: Remnants of poached Queen Conch (Lobatus gigas).

during field observations the Caribbean Spiny Lobster (*Panulirus argus*) is only minimally present, while it should be naturally abundant in this habitat, also indicates the targeting of this endangered and protected species.

Climate change vulnerability exacerbated by development

While the ecosystems of the fringing reef islands have all the capacity to be resilient to climate change and enhance our island's resilience to a changing climate, when these systems are constantly under pressure from developments and activities as described in this report, they can no longer withstand additional impacts and their cumulative effects, and consequently, their ecosystem services diminish.

4. Conservation and Management Strategies

4.1 Existing Legal and Policy Frameworks

The ecosystems and biodiversity of the reef island are protected by both national and regional policy frameworks, namely:

National legislation

- **Nature Protection Ordinance (AB 1995 no. 2):** Prohibits the destruction, disturbance, or exploitation of protected species and areas without explicit ecological justification and government exemption.
- **Decree on Protection of Flora and Fauna (AB 2017 no. 48):** Protects numerous species found on and near the reef islands and mangrove areas, including mangroves, seagrasses, corals and many associated species, such as sea turtles, parrotfish, conch and lobster.
- **Decree Designation of nature areas as Nature Reserves (AB 2020 no. 67):** Formally designates the reef islands and mangrove areas on the leeward and southern coast of Aruba as a nature reserve, permitting only nature-compatible management and access.
- **Aruba's Spatial Development Plan – ROPV (AB 2021 no. 123):** Designates the reef islands and mangrove areas as protected nature areas ('natuurgebied'), where physical developments are severely restricted to prevent degradation of natural values, and recreational use is only allowed under very strict conditions.

National Policy

- **National Biodiversity Strategy and Action Plan (NBSAP) 2024–2030:** Is a national contextualization of the CBD (see below) and emphasizes the conservation of vulnerable ecosystems and the precautionary principle, with objectives to:
    - Reduce threats to biodiversity.
    - Preserve and restore ecosystems.
    - Implement the precautionary principle.

  The NBSAP describes the Leeward coast of Aruba as comprising a range of interconnected habitats, including nearshore reefs, seagrass beds, mangrove, and other lagoonal systems – confirming the presence of the "Power of Three". It also explicitly highlights how these systems are under increasing pressure from human activity and climate change.

  The NBSAP prioritizes restoring degraded land, coastal, and marine ecosystems—with coral reefs, mangroves, and seagrass beds being specific examples of targeted habitats due to their importance for biodiversity, ecosystem services, and coastal resilience.

International/regional legal protection

- **Convention on Biological Diversity (CBD)** plays a crucial role in the protection of mangrove, seagrass, and coral ecosystems by promoting the conservation and sustainable use of biodiversity both within and outside protected areas. Through its Ecosystem Approach and Aichi Biodiversity Targets (and now the Kunming-Montreal Global Biodiversity Framework), the CBD encourages countries to integrate biodiversity considerations into national planning, including the restoration and sustainable management of coastal and marine ecosystems. It also supports the establishment of protected areas and the implementation of area-based conservation measures, ensuring that these vital ecosystems are preserved for their ecological functions and the services they provide to humans.

- **Specially Protected Areas and Wildlife (SPAW) Protocol (Cartagena Convention)**: Aruba is a contracting party to the SPAW Protocol, which mandates the protection of marine and coastal ecosystems of special value. The reef islands and mangrove areas as part of a Ramsar site, clearly meet the criteria for protected status under SPAW Annex I and II. Activities that disturb protected species or habitats are restricted or prohibited under this treaty.

- **Ramsar Convention**: As part of the designated Ramsar Site #2526 South Coast, the reef island and mangroves are recognized as Wetlands of International Importance. Signatory countries are obligated to promote sustainable strategies and maintain the ecological integrity of such sites.

Nature Conservation Management

- **ACF Protected Areas Conservation Management Framework 2025-2034** emphasizes the high importance of the protection, restoration, and sustainable management of mangrove, seagrass, and coral ecosystems. These ecosystems form the "Power of Three" and are treated as interconnected and essential to Aruba's biodiversity, climate resilience, and sustainable development.

- **ACF Coastal Protected Areas Conservation Management Plans 2025–2029** highlights the importance of reef islands and mangroves and their conservation as mangrove areas have already

been significantly reduced over the past decades due to unregulated coastal development, habitat fragmentation, and the growing impacts of climate change.

- **ACF Ramsar & Marine Protected Areas Conservation Management Plan 2025–2029** highlights the importance of the "Power of Three" – mangroves, seagrasses, and corals – as physically and functionally connected ecosystems and confirms that human access and development must be strictly regulated to reduce negative impacts. Only small-scale, sustainable, and nature-friendly activities are allowed under strict conditions in areas and zones designated by ACF.

4.2 Recommended Actions for Sustainable Reef Island Recreation

Environmental impact assessment (EIA), including the ecological and socio-economic environment

Prior to any further expansion or development of reef islands, it is imperative to conduct a comprehensive and multidisciplinary assessment of both the natural environment and existing human activities. This evaluation should serve as the foundation for informed decision-making and sustainable management. Key components of the assessment should include:

- Baseline Biodiversity and Ecosystem Surveys - Detailed inventories of flora, fauna, and ecological interactions to establish reference conditions and detect changes over time.
- Habitat Mapping - Spatial delineation of critical habitats such as coral reefs, seagrass beds, mangroves, and coastal vegetation, using remote sensing and field validation.
- Infrastructure and Use Mapping - Geospatial documentation of all existing structures, including ranchos, piers, and other facilities, with annotations on current usage, ownership, and proposed future functions.
- Risk and Threat Analysis - Identification and mapping of environmental pressures such as erosion, pollution, invasive species, climate change impacts, and unsustainable tourism practices.
- Carrying Capacity Assessment - Quantitative evaluation of the ecological and social limits to human activity, including thresholds for visitor numbers, infrastructure load, and resource extraction.

Evidence-based policy framework

Based on the outcomes of these assessments, an evidence-based policy framework can be developed to guide the sustainable use and management of reef islands. This policy should aim to balance human recreation and economic development with the protection, conservation, and restoration of the ecological integrity and natural heritage that make these fringing reef systems ecologically valuable and culturally significant.

4.3 Integrated Coastal Zone Management (ICZM)

To effectively address the mounting environmental pressures on Aruba's marine and coastal ecosystems, including the reef islands, a robust Integrated Coastal Zone Management (ICZM) strategy is essential. ICZM provides a comprehensive, science-based framework that harmonizes ecological integrity with sustainable human activities. It facilitates coordination among stakeholders—including government agencies, researchers, NGOs, local communities, and tourism operators—and ensures that

decision-making is rooted in ecosystem dynamics and long-term resilience. Core components of ICZM for Aruba's reef islands should include:

- Holistic Ecosystem Approach: Recognize and manage the reef islands, mangroves, seagrass beds, and coral reefs as a single, interconnected system where impacts in one area cascade across others.
- Zoning and Regulation: Establish clear and enforceable zoning that delineates areas for strict conservation, sustainable recreation, and controlled access, based on ecological sensitivity and carrying capacity assessments.
- Stakeholder Engagement: Facilitate inclusive dialogue and collaboration to ensure that all voices—particularly local and indigenous knowledge holders—are integrated into planning, monitoring, and enforcement.
- Adaptive Management: Monitor ecosystem health through continuous data collection and respond swiftly to emerging threats or changes in environmental conditions.
- Conflict Resolution Mechanisms: Proactively manage competing interests between development, recreation, and conservation through transparent mediation and participatory governance.
- Policy Integration: Align ICZM initiatives with broader national policies such as the NBSAP and the ROPV, and international agreements like the Ramsar Convention and SPAW Protocol to ensure compliance and global best practice.

ICZM offers a pathway for Aruba to balance recreational enjoyment with ecological preservation, setting a regional precedent for resilient coastal stewardship.

4.4 Nature-Based Solutions for Reef Island Rehabilitation

Incorporating Nature-Based Solutions (NbS) into the future management of reef islands and adjacent mangrove, seagrass and coral reef ecosystems offers a strategic pathway to restore ecological integrity while supporting sustainable human recreation. By prioritizing the rehabilitation and enhancement of Aruba's coral reefs, seagrass beds, and mangrove forests, these ecosystems can be revitalized into thriving, resilient networks capable of:

- Enhancing biodiversity through habitat restoration and connectivity
- Improving ecosystem services such as coastal protection, water filtration, and carbon sequestration
- Supporting sustainable recreation and tourism by maintaining the natural appeal and ecological health of the islands
- Increasing climate resilience by buffering against sea-level rise, storm surges, and temperature fluctuations

When integrated into spatial planning tools, stakeholder consultation, measurable ecological indicators and into the broader ICZM strategy, NbS serves as both a conservation and sustainability mechanism and a catalyst for eco-tourism, ensuring Aruba's reef islands remain vibrant, resilient, and cherished for generations. This approach aligns ecological restoration with long-term socio-economic benefits, making it a cornerstone of sustainable island stewardship.

5. Conclusions: Toward a Sustainable Future for Aruba's Reef Islands

The findings and implications described in this report underscore the ecological significance and vulnerability of Aruba's reef islands and their associated coastal and marine ecosystems—mangrove forests, seagrass meadows, and coral reefs. Collectively known as the "Power of Three," they form a tightly linked ecological network that delivers vital ecosystem services, including coastal protection, water purification, carbon sequestration, a refuge for numerous species of birds, and nursery habitats for a diverse array of marine life. Their continued health is not only essential for biodiversity conservation but also for sustaining Aruba's fisheries, tourism economy, and cultural heritage.

However, these natural values are increasingly under threat. Unregulated recreational development—particularly the construction and expansion of ranchos, piers, and artificial beaches—has led to habitat loss, fragmentation, pollution, and degradation of water quality. These impacts are compounded by indirect pressures such as eutrophication, wildlife disturbance, and illegal harvesting of protected species. The cumulative effect of these anthropogenic pressures is pushing these fragile ecosystems toward a tipping point, beyond which their ecological functions and services may be irreversibly compromised.

To mitigate these risks and guide future development, this report strongly recommends the implementation of a science-based Integrated Coastal Zone Management (ICZM) strategy. Such an approach must holistically address the interconnectedness of coastal and marine habitats and balance ecological integrity with sustainable human use. Key elements should include:

- Rigorous baseline assessments and habitat mapping
- Enforceable environmental regulations and zoning guidelines
- Adaptive management informed by continuous monitoring
- Nature-Based Solutions (NbS) to rehabilitate and enhance ecosystem resilience
- Cross-sectoral collaboration among government, NGOs, researchers, and local stakeholders

The long-term sustainability of Aruba's reef islands depends on coordinated action, informed policy, and community engagement. By aligning sustainable development goals with conservation priorities, Aruba has the opportunity to become a regional model for marine and coastal stewardship—preserving its natural heritage while fostering a resilient and inclusive blue economy.

This report serves as a foundational step towards that vision. Future efforts should build upon these insights with more detailed ecological studies, stakeholder consultations, and the development of a comprehensive reef island policy framework.

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Appendixes

Appendix 1: List of documented species for Aruba's reef islands and mangrove areas

Common name	***Scientific name***	**Art. 4 (AB 1995 no. 2)**	**SPAW annex**	**CITES**	**IUCN status**
Terrestrial invertebrates					
Monarch butterfly	*Danaus plexippus*				LC
Golden silk orb weaver	*Nephila clavipes*				LC
Lyside sulphur butterfly	*Kricogonia lyside*				
Drywood termite	*Cryptotermes cylindroceps*				
Caribbean hermit crab	*Coenobita clypeatus*				
Birds					
Peregrine Falcon	*Falco peregrinus*	1b	II	I	LC
Roseate Tern	*Sterna dougallii*	1b	II		LC
American Flamingo	*Phoenicopterus ruber*	1b	III		LC
Brown Pelican	*Pelecanus occidentalis*	1b			LC
Blue-tailed Emerald	*Chlorostilbon mellisugus*	2b			LC
Ruby-topaz Hummingbird	*Chrysolampis mosquitus*	2b			LC
Least Tern	*Sternula antillarum*		II		LC
Scarlet Ibis	*Eudocimus ruber*		III	II	LC
Blackpoll Warbler	*Setophaga striata*				NT
Reddish Egret	*Egretta rufescens*				NT
Semipalmated Sandpiper	*Calidris pusilla*				NT
American Golden-Plover	*Pluvialis dominica*				LC
Bananaquit	*Coereba flaveola*				LC
Bare-eyed Pigeon	*Patagioenas corensis*				LC
Belted Kingfisher	*Megaceryle alcyon*				LC
Black-bellied Plover	*Pluvialis squatarola*				LC
Black-crowned Night Heron	*Nycticorax nycticorax*				LC
Black-necked Stilt	*Himantopus mexicanus*				LC
Blue-winged Teal	*Spatula discors*				LC
Bobolink	*Dolichonyx oryzivorus*				LC
Brown Booby	*Sula leucogaster*				LC
Carib Grackle	*Quiscalus lugubris*				LC
Common Gallinule	*Gallinula galeata*				LC
Common Ground Dove	*Columbina passerina*				LC
Common Tern	*Sterna hirundo*				LC

Eared Dove	*Zenaida auriculata*				LC
Fork-tailed Flycatcher	*Tyrannus savana*				LC
Gray Kingbird	*Tyrannus dominicensis*				LC
Great Blue Heron	*Ardea herodias*				LC
Great Egret	*Ardea alba*				LC
Greater Yellowlegs	*Tringa melanoleuca*				LC
Green Heron	*Butorides virescens*				LC
Groove-billed Ani	*Crotophaga sulcirostris*				LC
House Sparrow	*Passer domesticus*				LC
Killdeer	*Charadrius vociferus*				LC
Laughing Gull	*Leucophaeus atricilla*				LC
Least Sandpiper	*Calidris minutilla*				LC
Lesser Yellowlegs	*Tringa flavipes*				LC
Little Blue Heron	*Egretta caerulea*				LC
Magnificent Frigatebird	*Fregata magnificens*				LC
Neotropic Cormorant	*Nannopterum brasilianum*				LC
Northern Scrub-Flycatcher	*Sublegatus arenarum*				LC
Northern Waterthrush	*Parkesia noveboracensis*				LC
Osprey	*Pandion haliaetus*				LC
Pectoral Sandpiper	*Calidris melanotos*				LC
Pied-billed Grebe	*Podilymbus podiceps*				LC
Rock Pigeon	*Columba livia*				LC
Roseate Spoonbill	*Platalea ajaja*				LC
Royal Tern	*Thalasseus maximus*				LC
Ruddy Turnstone	*Arenaria interpres*				LC
Sanderling	*Calidris alba*				LC
Sandwich Tern	*Thalasseus sandvicensis*				LC
Semipalmated Plover	*Charadrius semipalmatus*				LC
Shiny Cowbird	*Molothrus bonariensis*				LC
Short-billed Dowitcher	*Limnodromus griseus*				LC
Snowy Egret	*Egretta thula*				LC
Solitary Sandpiper	*Tringa solitaria*				LC
Sora	*Porzana carolina*				LC
Southern Lapwing	*Vanellus chilensis*				LC
Spotted Sandpiper	*Actitis macularius*				LC
Stilt Sandpiper	*Calidris himantopus*				LC
Tricolored Heron	*Egretta tricolor*				LC

Tropical Mockingbird	*Mimus gilvus*				LC
Venezuelan Troupial	*Icterus icterus*				LC
Western Cattle Egret	*Bubulcus ibis*				LC
Whimbrel	*Numenius phaeopus*				LC
White-cheeked Pintail	*Anas bahamensis*				LC
White-tipped Dove	*Leptotila verreauxi*				LC
Willet	*Tringa semipalmata*				LC
Wilson's Snipe	*Gallinago delicata*				LC
Yellow Oriole	*Icterus nigrogularis*				LC
Yellow Warbler	*Setophaga petechia*				LC
Yellow-billed Cuckoo	*Coccyzus americanus*				LC
Yellow-crowned Night Heron	*Nyctanassa violacea*				LC
Lesser Black-backed Gull	*Larus fuscus*				LC
Collared Plover	*Charadrius collaris*				LC
Stony corals					
Elkhorn coral	*Acropora palmata*	1b	II	II	CR
Staghorn coral	*Acropora cervicornis*	1b	II	II	CR
Blue crust coral	*Porites cf. branneri*	1b	III	II	CR
Massive starlet coral	*Siderastrea siderea*	1b	III	II	CR
Maze coral	*Meandrina meandrites*	1b	III	II	CR
Pillar coral	*Dendrogyra cylindrus*	1b	III	II	CR
Symmetrical brain coral	*Pseudodiploria strigosa*	1b	III	II	CR
Lobed star coral	*Orbicella annularis*	1b	III	II	EN
Boulder brain coral	*Colpophyllia natans*	1b	III	II	VU
Lettuce coral	*Agaricia agaricites*	1b	III	II	VU
Golfball coral	*Favia fragum*	1b	III	II	LC
Lesser starlet coral	*Siderastrea radians*	1b	III	II	LC
Mustard hill coral	*Porites astreoides*	1b	III	II	LC
Thin finger coral	*Porites divaricata*	1b	III	II	LC
Finger coral	*Porites porites*	1b	III	II	LC
Yellow pencil coral	*Madracis auretenra*	1b	III	II	LC
Fish					
Bucktooth parrotfish	*Sparisoma radians*	2b			LC
Princess parrotfish	*Scarus taeniopterus*	2b			LC
Queen parrotfish	*Scarus vetula*	2b			LC
Rainbow parrotfish	*Scarus gaucamaia*	2b			NT
Redband parrotfish	*Sparisoma aurofrenatum*	2b			LC
Redtail parrotfish	*Sparisoma chrysopterum*	2b			LC

Stoplight parrotfish	*Sparisoma viride*	2b			LC
Striped parrotfish	*Scarus iserti*	2b			LC
Atlantic tarpon	*Megalops atlanticus*				VU
Cubera snapper	*Lutjanus cyanopterus*				VU
Peppermint goby	*Coryphopterus lipernes*				VU
Lane snapper	*Lutjanus synagris*				NT
Mutton snapper	*Lutjanus analis*				NT
Banded butterflyfish	*Chaetodon striatus*				LC
Bandtail puffer	*Sphoeroides spengleri*				LC
Beaugregory	*Stegastes leucostictus*				LC
Bicolor damselfish	*Stegastes partitus*				LC
Black margate	*Anisotremus surinamensis*				DD
Blue chromis	*Chromis cyanea*				LC
Blue tang	*Acanthurus coeruleus*				LC
Bluehead	*Thalassoma bifasciatum*				LC
Bluestriped grunt	*Haemulon sciurus*				LC
Brown chromis	*Chromis multilineata*				LC
Chain moray	*Echidna catenata*				LC
Cleaning goby	*Gobiosoma genie*				LC
Cocoa damselfish	*Stegastes variabilis*				LC
Coney	*Cephalopholis fulva*				LC
Doctorfish	*Acanthurus chirurgus*				LC
Dusky damselfish	*Stegastes adustus*				LC
Foureye butterflyfish	*Chaetodon capistratus*				LC
French angelfish	*Pomacanthus paru*				LC
French grunt	*Haemulon flavolineatum*				LC
Glassy Sweeper	*Pempheris schomburgkii*				LC
Goldentail moray	*Gymnothorax miliaris*				LC
Goldspotted eel	*Myrichtys ocellatus*				LC
Gray snapper	*Lutjanus griseus*				LC
Great barracuda	*Sphyraena barracuda*				LC
Green moray	*Gymnothorax funebris*				LC
Harlequin bass	*Seranus tigrinus*				LC
Honeycomb cowfish	*Acanthostracion polygonius*				LC
Lionfish	*Pterois volitans*				LC
Mahogony snapper	*Lutjanus mahogani*				

Ocean surgeonfish	*Acanthurus tractus*				LC
Orangespotted filefish	*Cantherhines pullus*				LC
Palehead blenny	*Labrisomus gobio*				LC
Peacock flounder	*Bothus lunatus*				LC
Porcupinefish	*Diodon hystrix*				LC
Puddingwife	*Halichoeres radiatus*				LC
Redlip blenny	*Ophioblennius atlanticus*				LC
Rock beauty	*Halocanthus tricolor*				LC
Roughhead blenny	*Acanthemblemaria aspera*				LC
Schoolmaster	*Lutjanus apodus*				LC
Sergeant major	*Abudefduf saxatilis*				LC
Sharpnose puffer	*Canthigaster rostrata*				LC
Silversides	*Atherinidae spp.*				LC
Slippery dick	*Halichoeres bivittatus*				LC
Smallmouth grunt	*Haemulon chrysergyreum*				LC
Smooth trunkfish	*Lactophrys triqueter*				LC
Spanish hogfish	*Bodianus rufus*				LC
Spotfin butterflyfish	*Chaeton ocellatus*				LC
Spotted goatfish	*Pseudupeneus maculatus*				LC
Spotted scorpionfish	*Scorpaena plumieri*				LC
Squirrelfish	*Holocentrus adscensionis*				LC
Threespot damselfish	*Stegastes planifrons*				LC
Trumpetfish	*Aulostomus maculatus*				LC
Yellow goatfish	*Mulloidichthys martinicus*				LC
Yellowfin mojarra	*Gerres cinereus*				LC
Yellowtail damselfish	*Microspathodon chrysurus*				LC
Yellowtail snapper	*Ocyurus chrysurus*				DD
Gorgonians					
Common sea fan	*Gorgonia ventalina*	1b			
Encrusting gorgonian	*Erythropodium caribaeorum*	1b			
Encrusting zoanthid	*Palythoa caribaeorum*	1b			
Knobby sea rods	*Eucinea spp.*	1b			
Orange spiny sea rod	*Muricea elongata*	1b			
Sea plumes	*Antillogorgonia spp.*	1b			

Slit-pore sea rods	*Plexaurella pss.*	1b			
Yellow sea whip	*Pterogorgia citrina*	1b			
Hydrocorals					
Blade fire coral	*Millepora complanata*	1b	III	II	CR
Branching fire coral	*Millepora alcicornis*	1b	III	II	VU
Ridged fire coral	*Millepora striata*	1b	III	II	VU
Marine invertebrates					
Queen conch	*Lobatus (Strombus) gigas*	1b	III	II	
Caribbean spiny lobster	*Panulirus argus*	1b	III		DD
Long-spined urchin	*Diadema antillarum*	2b			
Amber penshell	*Pinna carnea*				
Atlantic yellow crowrie	*Erosaria acicularis*				
Bearded fireworm	*Hermodice carunculata*				
Banded coral shrimp	*Stenopus hispidus*				
Blue crab	*Callinectes sapidus*				
Brown fanworm	*Notaulax nudicollis*				
Christmas tree hydroid	*Pennaria disticha*				
Christmas tree worm	*Spirobranchus giganteus*				
Flamingo tongue	*Cyphoma gibbosum*				
Four-tooth nerite	*Nerita versicolor*				
Fringeback dondice	*Dondice occidentalis*				
Giant anemone	*Condylactis gigantea*				
Giant hermit	*Petrochirus diogenes*				
Hermit crab	*Paguroidea spp.*				
Knobby anemone	*Ragactis lucida*				
Lettuce slug	*Elysia crispata*				
Magnificent feather duster	*Sabellastarte magnifica*				
Mangrove tunicate	*Ecteinascidia turbinata*				
Painted tunicate	*Clavelina picta*				
Rock-boring urchin	*Echinometra lucunter*				
Sally lightfoot	*Grapsus grapsus*				
Stocky cerith	*Cerithium litteratum*				
Upside-down jellyfish	*Cassiopea xamachana*				
West Indian fuzzy chiton	*Acanthopleura granulata*				
West indian sea egg	*Tripneustes ventricosus*				
Yellowline arrow crab	*Stenorhynchus seticornis*				

Reptiles					
Hawksbill sea turtle	*Eretmochelys imbricata*	1b	II	I	CR
Green turtle	*Chelonia mydas*	1b	II	I	EN
Loggerhead sea turtle	*Caretta caretta*	1b	II	I	VU
Green iguana	*Iguana iguana*	1b		II	LC
Anolis lizard	*Anolis lineatus*	1b			NT
Aruba whiptail lizard	*Cnemidophorus arubensis*				LC
Macroalgae					
Bristle ball brush	*Penicillus dumetosus*				
Cactus tree alga	*Caulerpa cupressoides*				
Encrusting fan-leaf alga	*Lobophora variegata*				
Flat green feather alga	*Caulerpa mexicana*				
Green grape alga	*Caulerpa racemosa*				
Green net algae	*Microdictyon boergesenii*				
Leafy flat-blade alga	*Stypopodium zonale*				
Mermaid's fans	*Udotea spp.*				
Saucer blade alga	*Avtainvillea asarifolia*				
Serrated strap alga	*Dictyota ciliolata*				
Three finger leaf alga	*Halimeda incrassata*				
White scroll alga	*Padina sanctae-crucis*				
Y-branched alga	*Dictyota spp.*				
Y-twig alga	*Amphiroa rigida*				
Corallinaceae					
Crustose coralline algae	*Rhodopyta*	1a			
Reef cement	*Rhodopyta*	1a			
Terrestrial flora					
Seagrape	*Coccoloba uvifera*				LC
Sea purslane	*Sesuvium portulacastrum*	1a			LC
Mangroves					
Red mangrove	*Rhizophora mangle*	2a	III		LC
White mangrove	*Laguncularia racemosa*	2a	III		LC
Black mangrove	*Avicennia germinans*	2a	III		LC
Buttonwood mangrove	*Conocarpus erectus*	2a	III		LC
Seagrass					
Manatee grass	*Syringodium filiforme*	1a	III		LC
Turtle grass	*Thalassia testudinum*	2a	III		LC
Broadleaf seagrass	*Halophila stipulacea*				LC

Sponges					
Lumpy overgrowing sponge	*Desmapsamma anchorata*				
Orange icing sponge	*Mycale laevis*				
Red boring sponge	*Cliona delitrix*				
Scattered pore rope sponge	*Aplysina fulva*				
Stinker sponge	*Ircinia felix*				