MARINE BIODIVERSITY IN VENEZUELA: STATUS AND PERSPECTIVES

BIODIVERSIDAD MARINA EN VENEZUELA: ESTADO ACTUAL Y PERSPECTIVAS

Patricia Miloslavich[1,2], Eduardo Klein[1,2], Edgard Yerena[1] & Alberto Martin[1,2]

[1]Departamento de Estudios Ambientales, Universidad Simón Bolívar, Caracas, Venezuela.
[2]Instituto de Tecnología y Ciencias Marinas (INTECMAR), Universidad Simón Bolívar, Caracas, Venezuela.

ABSTRACT

Venezuela is among the ten countries with the highest biodiversity in the world, both in the terrestrial and the marine environment. Due to its biogeographical position, Venezuelan marine flora and fauna are composed of species from very different marine bioregions such as the Caribbean and the Orinoco Delta. The ecosystems in the Caribbean have received considerable attention but now, due to the tremendous impact of human activities such as tourism, over-exploitation of marine resources, physical alteration, the oil industry, and pollution, these environments are under great risk and their biodiversity highly threatened. The most representative ecosystems of this region include sandy beaches, rocky shores, seagrass beds, coral reefs, soft bottom communities, and mangrove forests. The Orinoco Delta is a complex group of freshwater, estuarine, and marine ecosystems; the habitats are very diverse but poorly known. This paper summarizes the known, which is all of the information available in Venezuela about research into biodiversity, the different ecosystems and the knowledge that has become available in different types of publications, biological collections, the importance and extents of the Protected Areas as biodiversity reserves, and the legal institutional framework aimed at their protection and sustainable use. As the unknown, research priorities are proposed: a complete survey of the area, the completion of a species list, and an assessment of the health status of the main ecosystems on a broad national scale. This new information must be integrated and summarized in nationwide Geographic Information Systems (GIS) databases, accessible to the scientific community as well as to the management agencies. In the long term, a genetic inventory must be included in order to provide more detailed knowledge of the biological resources. Future projects at the local (Venezuela), regional (Southern Caribbean: Colombia, Venezuela, and the Netherlands Antilles), and global (South America) scales are recommended.

KEYWORDS: Venezuela, marine biodiversity, conservation, protected areas, biological collections.

RESUMEN

Venezuela se encuentra entre los primeros 10 países con la mayor biodiversidad en el mundo, tanto en el ambiente terrestre como en el marino. Dada su posición biogeográfica, la flora y fauna marina venezolana está compuesta por especies de biorregiones muy distintas como lo son el Caribe y el Delta del Orinoco. En el Caribe, los ecosistemas han recibido una atención considerable, sin embargo, debido al tremendo impacto de actividades humanas tales como el turismo, sobreexplotación de recursos marinos, alteración física, la industria petrolera y contaminación, entre otras, estos ambientes se encuentran bajo un gran riesgo y su biodiversidad está altamente amenazada. Los ecosistemas más representativos de esta región incluyen las playas arenosas, litorales rocosos, praderas de fanerógamas marinas, arrecifes coralinos, comunidades de fondos blandos y bosques de manglar. El Delta del Orinoco está constituido por un grupo muy complejo de ecosistemas marinos, estuarinos y dulceacuícolas, los hábitats son muy diversos pero hay muy poca información disponible acerca de este sistema. En este trabajo resumimos lo conocido, lo cual es toda la información disponible en Venezuela acerca de la investigación científica en biodiversidad, los diferentes ecosistemas y el grado de conocimiento que ha sido generado a través de diversos tipos de publicaciones, las colecciones biológicas, la importancia y el alcance de las áreas protegidas como reservas de biodiversidad y el marco legal institucional dirigido hacia su protección y uso sustentable.

Igualmente, para lo desconocido, proponemos como prioridad de investigación la estimación de área, el listado completo de las especies y el estado de salud de los principales ecosistemas a una escala a nivel nacional. Esta nueva información debe ser integrada y resumida en bases de datos de sistemas de información geográfica, accesible a la comunidad científica así como a las agencias encargadas de los planes de manejo. A largo plazo, un inventario genético debería incluirse como una necesidad para establecer un mejor conocimiento de los recursos biológicos. Proponemos posibles proyectos a futuro en una escala local (Venezuela), regional (Caribe Sur: Colombia, Venezuela y las Antillas) y global (América del Sur).

PALABRAS CLAVES: Venezuela, biodiversidad marina, conservación, áreas protegidas, colecciones biológicas.

INTRODUCTION

Venezuela is among the ten countries with the highest biodiversity in the world. This richness of species is present in both the terrestrial and the marine environments. Due to its biogeographical position, the flora and fauna of Venezuela are characterized by species from the very different marine bioregions of the Caribbean and the Orinoco Delta, as well as the continental bioregions such as the Andes, the Amazon, and Guyana. The Caribbean coastal ecosystems have received considerable attention but, due to the great impact of human activities such as tourism, the over-exploitation of marine resources, physical alteration, the oil industry, and pollution, among others, these environments and their biodiversity are highly threatened. This region includes sandy beaches, rocky shores, seagrass habitats, coral reefs, soft bottom communities, and mangrove forests.

The Orinoco River has a basin of 990,000 km² and its delta is made up of a complex group of freshwater, estuarine and marine ecosystems. The habitats are very diverse and the whole system plays an important role in regulating the input of almost 36,000 m^3 of water per second to the Atlantic Ocean (Meade *et al*. 1983; Millman & Meade 1983), the Orinoco being the third largest river in the world in terms of discharge (Palacios 1999). This deltaic ecosystem is little studied but, in 2001, the Ministerio del Ambiente y de los Recursos Naturales (Ministry of Environment and Natural Resources, MARN) decided to support a rapid ecological assessment of this biosphere reserve with a view to its future conservation and sustainable use. This program is very broad, being the subproject of aquatic fauna under the coordination of the Universidad Simón Bolívar, it is considered to be a national priority and will be a long term study (9 years) supported by the Global Environmental Fund (GEF).

This paper firstly outlines the physical and oceanographic features of the Venezuelan marine domain and describes the bioregions of the country. Then, in relation to the status of marine biodiversity in Venezuela, the projects implemented to promote the sustainable use of marine resources-scientific research, the establishment of protected areas, biological collections, the legal institutional framework that protects the environment and natural resources, and other initiatives such as non-governmental organizations (NGOs)-are discussed.

THE PHYSICAL AND OCEANOGRAPHIC CHARACTERISTICS OF THE VENEZUELAN MARINE DOMAIN

Venezuela is located at the north of South America, between 00°45’ and 15°40’N and between 59°47’and 73°22’W. Its northern limits are the Dominican Republic and the Caribbean Sea (the West Indies, Puerto Rico, the French islands Martinique and Guadalupe, and the American Virgin Islands). In the east, it extends to Guyana, the Atlantic Ocean, and the Caribbean Sea (Trinidad and Tobago). Its southern neighbors are Brazil and Colombia, the latter also being at its western limit.

The terrestrial domain covers 916,425 km² and the maritime territory, 860,000 km² (Lara de González *et al.* 1997; Rodríguez-Altamiranda 1999). The coastal zone of the Venezuelan Caribbean is very diverse in geological and topographical features. It has approximately 3,964 km of continental coastline of which 68% fronts the Caribbean Sea and 21%, the Atlantic Ocean (Rodríguez-Altamiranda 1999). The remaining 12% of the Venezuelan coastline corresponds to clusters of more than 300 islands and keys with a total dry land area of about 1270 km^2; most of the islands and keys are included in 14 archipelago complexes located south of 12°12´ N, with the exception of the Isla de Aves which is located north of 15° N (MARNR 1979).

The climate of continental Venezuela is influenced by the intertropical convergence zone (ITCZ) of the trade winds from the northeast and southeast, but that of the maritime region is mainly dependent upon only the northeast trade winds and the ITCZ. The coast is in the normal path of the Caribbean hurricanes which affect the area (with the exception of the Isla de Aves) during the rainy season. Even their passage away from the mainland can influence the coastal weather by causing significant rainfall, sea swell, and high winds. As a consequence and due to the geomorphological characteristics of Venezuela, the country has a range of climatic situations. Annual precipitation may vary from less than 400 mm in the arid and semiarid zones of the coastal and central regions to more than 4000 mm in the south of the country. Mean daily temperatures vary between 28°C in most of the country and 0°C in the mountains of the Andes (MARN 2000).

The sea surface temperature (SST) along the Venezuelan coastline is affected by several cold upwelling fronts which vary in form, extent, and intensity. The SST varies annually between 20º and 29°C with a daily oscillation of between 0º and 2.5°C (Penchaszadeh *et al.* 2000). The north-south oscillation of the ITCZ constitutes the main cause of seasonal changes in the salinity and temperature of Caribbean Sea surface waters (Muller-Karger & Varela 1989).

Twelve upwelling zones have been identified along the coast of Venezuela by means of Advanced Very High Resolution Radiometer (AVHRR) images of SST which, during upwelling events, may decrease by between 5º and 7°C from the normal 24-26°C. On the west coast, the upwelling zones are located west of the Goajira Peninsula, in the Gulf of Venezuela, and at Punto Fijo near the Paraguaná Peninsula, Cabo San Román, and Puerto Cumarebo. On the central coast, the upwelling at Cabo Codera is unusual since, on occasions, it has been observed when there were no other upwelling fronts. There are also several important upwelling systems on the east coast between Puerto La Cruz and Cumaná, north of the Araya Peninsula and Margarita Island, and close to Carúpano. Upwelling occurs simultaneously at all of these locations, driven by the strong winds during the first 6 months of the year. Its intensity and propagation are considerable, spreading over 200,000 km² and contributing to the most productive area known in the Caribbean Sea. Off the Paria Peninsula and north of Trinidad, upwelling takes place for only a limited period and is of variable intensity, the cold water sometimes forming mesoscale eddies towards the northwest, probably due to the displacement of less dense, warmer waters from the Gulf of Paria (Penchaszadeh *et al.* 2000).

The productivity of the coastal waters is determined mainly by the upwelling dynamics and the uptake of alochthonous material coming from large rivers and lakes. The eastern part of the coast is the most productive area, though seasonal, depending on the strength of upwelling and the Orinoco river discharge. This zone maintains seasonal concentrations of chlorophyll *a* of more than 3 mg l^{-1} and a total annual fish production of between 200,000 and 250,000 tons. The productivity of the Gulf of Venezuela is also sustained by the nutrients coming from the Maracaibo Lake basin. The Gulf and its coastal areas have been affected by oil extraction and the petrochemical industry for more than 60 years, so that moderate to high levels of contamination are found in some local environments such as Tablazo Bay (at the mouth of the Maracaibo Lake estuary) and Amuay Bay (Paraguaná Península).

THE MAJOR MARINE ECOSYSTEMS AND BIOREGIONS OF VENEZUELA

The coast of Venezuela is very diverse in geological and topographical terms and the shallow water marine environments include sandy beaches, rocky shores, seagrass beds, coral reefs, mangroves, and coastal lagoons (Penchaszadeh *et al.* 2000).

Sandy beaches have been classified according to wave energy, sediment origin and particle size as: (1) dissipative beaches with fine and very fine sediments, rich in organic matter; (2) high energy beaches with coarse sediments and an intermediate content of organic matter; and (3) low energy beaches of carbonate biogenic sediments with a variable content of organic matter. Biodiversity in the first type is very low, with few though very abundant and dominant species; these beaches are however very important since they are used by fish as nursery grounds and food sources. High energy beaches have a diverse taxonomic composition with no dominant species and scarce ichthyofauna while, in the third type of beaches, biodiversity is again very low and the fish fauna are usually associated with nearby coral reefs and seagrass beds (Penchaszadeh *et al*. 2000)

Rocky shores are areas of great diversity with a variety of microhabitats. They have characteristic zonation patterns and 3 zones can be distinguished: (1) supralittoral, (2) midlittoral, and (3) infralittoral. The upper and lower supralittorals are characterized by, respectively, a *Littorina* zone and a barnacle zone. The midlittoral is populated mainly by algae, the species composition depending on wave exposure, and the crevices and holes in the rocks are inhabited by several types of echinoderm and other invertebrates. The sublittoral zone is characterized by small aggregations of corals and hydrocorals (Penchaszadeh *et al*. 2000).

Seagrasses are widely distributed along the coast. Eight species have been reported in Venezuela, *Thalassia testudinum* being the most common (Acosta 1974, Ganesan 1989, Vera 1992, Pérez 1997). The biodiversity of invertebrates and fish associated with *Thalassia* beds has been found to be very high due to the great productivity of this seagrass and the diversity of microhabitats in the environments studied, the National Parks of Morrocoy, Mochima, and Los Roques (Bitter 1988, Villamizar 1993, Isea 1994, Díaz 1997, Galindo 1997, Bone *et al*. 1998, Noriega 1998, Atienza 2000; Huck 2001).

Coral reefs are well developed around the offshore islands. The reef fauna are similar to those in the rest of the Caribbean with more than 40 scleractinian coral species. Few localities on the continental coastline have significant reef development due to river discharge though, in the western sector of the coast, reefs can be found in the Morrocoy and San Esteban National Parks and in the center of the coast in Turiamo Bay (Woodley *et al*. 1997, Bone *et al*. 2001)

Mangrove forests cover an area of approximately 673,000 ha along the coastline (Conde & Alarcón 1993), the greatest areas of mangrove being located in the Orinoco Delta and the Gulf of Paria. Mangrove forests have horizontal zonations from the sea to inland, *Rhizophora mangle* being the most seaward species followed by *Avicennia germinans*, *Laguncularia racemosa*, and *Conocarpus erectus* which prospers on firm sandy soil away from the tides (Pannier & Pannier 1989). Vertically, the mangrove community is also very complex; the sediments underneath the trees are muddy with several infaunal bivalve species and the roots are covered mainly with sponges with a highly diverse associated fauna and hydrocorals (Sutherland 1980, Morao 1983, Ordosgoitti 1985, Díaz *et al*. 1992).

Coastal lagoons cover an area of approximately 26,900 ha, distributed between 25 lagoons present from the Goajira Peninsula in the west to Sucre State and Nueva Esparta State (Margarita, Coche, and Cubagua islands) in the east, each of them characterized by a particular ecosystem (Penchaszadeh *et al*. 2000).

Venezuela has been classified into 7 biogeographical regions, or simply bioregions, based on topography, climate, and vegetation (Eisenberg & Redford 1979). More recently MARN (2000), taking into account other ecological variables such as flora, altitude, temperature, annual precipitation, and whether it was a continental or marine environment, defined 10 bioregions. Of these, three are maritime: (1) Continental coastal, (2) Marine, and (3) Insular.

The continental coastal bioregion

This region constitutes 3,964 km of continental coastline and includes all of the coastal systems between altitudes of 0 and 100 m. The temperatures are high (28°C) and the main type of vegetation is mangroves. The coasts are classified as high (cliffs) or low. The high coasts correspond to elevated relieves that descend abruptly to the sea and have vertical zonations in horizontal fringes with characteristic marine flora and fauna. The low coasts are represented by muddy, sandy, and mixed beaches, as well as by numerous wetlands. On the Atlantic coast, the latter are characterized by vast flooded plains like the San Juan River and the Orinoco Delta and, on the Caribbean coast, by coastal lagoons.

The marine bioregion

This region, the Venezuelan economic exclusive zone (EEZ), occupies about 860,000 km² of marine and submarine areas of the territorial waters, a surface which is comparable to that of the continental territory. The floral and faunal diversity on the Atlantic side is relatively low but very little information exists regarding the habitats there, which are dominated by great quantities of mud and sand brought down by the Orinoco, Esequibo, and Amazon rivers. The Caribbean side is more diverse water transparency is higher and increases from east to west and from south to north. The ecosystems found throughout this region are basically soft bottoms, with and without seagrass beds, and coral reefs with a high biological diversity.

THE INSULAR BIOREGION

This region is made up of 314 territories. The islands Margarita, Coche, and Cubagua form the Nueva Esparta State and the remaining 311 keys, islets and islands constitute the Federal Dependencies. Several of these islands are grouped in archipelagos such as Los Roques, Los Frailes, Los Testigos, Los Hermanos, and Las Aves among others. The island of Patos is the only federal dependency in the Atlantic Ocean, the remainder being in the Caribbean Sea. The insular territories are characterized by mangroves, coral reefs, seagrass beds, sandy beaches, and rocky shores.

From a more ecological point of view, however, and taking into account the types of marine ecosystems found on the coast of Venezuela, it is here proposed that a better and more accurate breakdown of the marine domain would be its division into 12 ecoregions (Fig. 1).

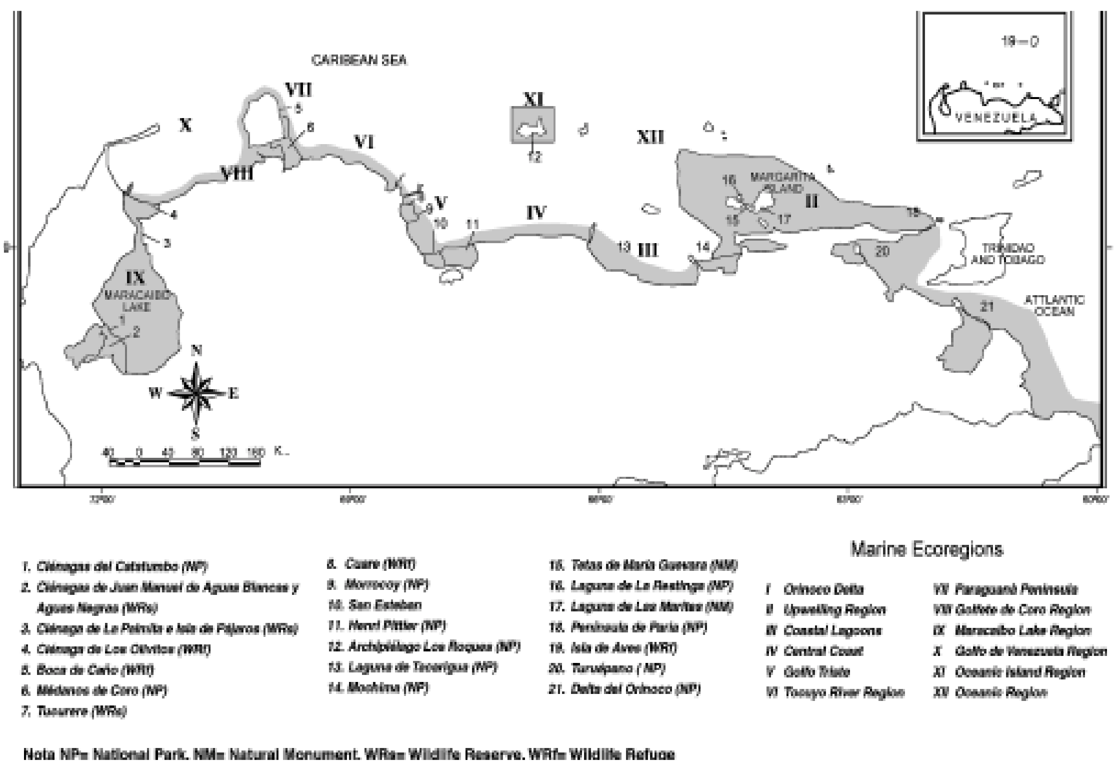

FIGURE 1. Coastal marine protected areas and marine ecoregions of Venezuela.

FIGURA 1. Areas costeras marinas protegidas y ecorregiones marinas de Venezuela.

Ecoregion 1: The Orinoco Delta and the Atlantic coast, estuarine and marine ecosystems, heavy sediment loads, high turbidity, sandy and muddy bottoms. Well developed mangrove communities.
Ecoregion 2: The eastern upwelling region, from the east of the Paria Peninsula to Mochima Bay. It is characterized by shallow continental shelf with coarse sandy bottoms and rocky shores. No important reef formation but limited coral development. High primary and secondary production due to seasonal upwelling fronts. Includes the Cariaco trench and the islands of Margarita, Coche, Cubagua, Los Frailes, Los Hermanos, and Los Testigos.
Ecoregion 3: Píritu-Tacarigua region. From Barcelona to Cabo Codera. Shallow coastal lagoons and sandy beaches, high sediment loads from the Unare and Tuy rivers. It is characterized by high secondary production, mostly of crustaceans and bivalves.
Ecoregion 4: Central coast. From Cabo Codera to Patanemo Bay. It is characterized by narrow continental margin regions, by rocky shores and coarse sandy beaches. Coral communities associated to the rocky substrates. It has high water transparency.
Ecoregion 5: Golfo Triste region. From Patanemo Bay to Tocuyo River. Shallow continental shelf, moderate secondary production, sandy beaches, and well developed coastal coral reefs. It has coral key formations in the Morrocoy and San Esteban National Parks.
Ecoregion 6: Tocuyo region. From the Tocuyo River, to the east of the Paraguaná Peninsula Isthmus. Characterized by sandy beaches and rocky cliffs. High sediment load from the Tocuyo, Hueque and Ricoa rivers. Low water transparency
Ecoregion 7: Paraguaná region. From the Paraguaná Isthmus to Punta Cardón. Characterized by emerged rocky shores, with large beds of macroalgaes. Carbonate sand beaches. High primary productivity due to upwelling fronts.
Ecoregion 8: Golfete de Coro region. From Punta Cardón to the mouth of the Maracaibo Estuary, including Golfete de Coro. Shallow water region with high sediment loads due to resuspended matter from Golfete de Coro. Characterized by high secondary production, mainly shrimps and sciaenid fish.
Ecoregion 9: Maracaibo estuary region. It is an estuarine system, maintained by the dredging of a navigation channel through the Maracaibo strait. Characterized by high primary and secondary production of shrimps and bivalves. High pollution risks due to oil industry.
Ecoregion 10: Golfo de Venezuela region. Characterized by wide platform shelf and shallow bottoms (< 50m). High primary and secondary production of shrimp due to large upwelling fronts. Bottom communities dominated by detritivorous organisms.
Ecoregion 11: The insular region. Includes all emerged territories with the exception of those included in the eastern upwelling region. Characterized by solitary islands and archipielagos. Well developed reefs and seagrass beds, with very high diversity. Mangrove forests on some islands. Some sea turtle nest beaches and rich marine bird communities.
Ecoregion 12: The oceanic region. The territorial and EEZ waters, ranging from 100m to more than 3000m deep. Biodiversity poorly known. Some areas have moderately high pelagic productivity due to the effects of adjacent upwelling areas.

Biodiversity in Venezuela

The book, "Venezuela: Un país megadiverso" edited by Aguilera *et al*. (2003) demonstrates very clearly the high level of biodiversity in the country. The concept of biodiversity is complex and incorporates the idea of the richness of the biota at the genetic, specific and ecological level, each of them sharing particular characteristics and interrelationships (Crisci *et al*. 1996). Species and ecosystem diversities have received the greatest attention, genetic diversity being known only partially for some species.
As far as the biodiversity of marine species is concerned, the best studied groups are fish (Cervigón 1966, 1989, 1991a, 1991b, 1994, 1996; Cervigón & Fisher 1979; Cervigón *et al*. 1992; Cervigón & Alcalá 1999, 2000), decapod crustaceans (Rodríguez 1980), amphipod crustaceans (Díaz, 2001; Martín 2002), corals (Ramírez-Villaroel 2001), and molluscs (Lodeiros *et al*. 1999).
Aguilera (2000) stated that the most important facilities available in Venezuela for promoting the conservation and sustainable use of the biological resources are:
(1) Research carried out by highly qualified personnel with an extensive scientific background actively working on biodiversity;

(2) The national system of Protected Areas (PA) and Areas under a special administrative regime (ABRAE) which include more than half of the Venezuelan continental territory and some important archipelagos;
(3) The biological collections of preserved and living organisms; and
(4) All of the laws, rules, and regulations as well as international agreements which engage the country in structuring a strategy for gathering knowledge about the sustainable use of biological resources without reducing diversity.

(1) Research priorities in the study of biodiversity in Venezuela

For a country such as Venezuela, research and evaluation of its biological diversity will be a long term study, given the enormous biotic richness within its territory. The Agreement on Biological Diversity defines, in Article 12, the special need of the developing countries to promote research programs and methods in the identification, conservation, and sustainable use of the biological resources. Most of this research in Venezuela is carried out in national universities and research institutes. In the western sector of the coast, past and future research on the estuarine system of Lake Maracaibo has been and will be centered on the Institute for the Conservation of Lake Maracaibo (ICLAM) and Universidad del Zulia (LUZ). Studies at the Universidad Central de Venezuela (UCV), Universidad Simón Bolívar (USB), and the Venezuelan Institute of Scientific Research (IVIC) in Caracas and the Universidad Experimental Francisco de Miranda (UNEFM) are focused mostly on the central west coast and on the east coast, the largest research centers being the Universidad de Oriente (UDO) and the Fundación La Salle de Ciencias Naturales (FLASA). The National System in Science and Technology is coordinated by CONICIT (the National Council for Scientific Research), renamed FONACIT (the National Fund for Science, Technology and Innovation) in 2002. FONACIT has two committees which deal with biological diversity: the National Commission for Biotechnology and the National Commission for Oceanology. Currently, FONACIT has 4 priority programs concerned with the environment and biological resources, two of them directly related to marine ecology: (1) biological diversity and (2) oceanology.
Within the biological diversity agenda, there are 15 projects, but only one dealing with marine ecosystems. This is a study of the biodiversity of the Olivitos system, Zulia State, at the mouth of Lake Maracaibo. The oceanology program has four themes which were identified as priorities during a workshop on Marine Science and Technology held in 1996: (1) Fisheries and aquaculture; (2) Morrocoy National Park; (3) the Orinoco Delta and Paria Gulf; and (4) Research on coastal processes.

The Morrocoy National Park: An example of a national Oceanology program

Morrocoy National Park (10°52’N, 69°16’W) is located on the northwestern coast of Golfo Triste (Betz & Bock 1981). The diurnal temperature variation of the surface waters fluctuates between 27° and 32°C where oceanic influences prevail. The salinity ranges from 30 to 38‰ (Bitter, 1988) but varies much less. away from the coast. Mean annual precipitation is 1,213 mm and varies seasonally. The 32,090 ha (320 km²) park includes continental, insular, and marine ecosystems. Two marine zones, offshore and inshore, are distinguishable. The offshore zone is connected to the open ocean and characterized by coralline communities, moderate swells, low turbidity, and water depths of up to 20 m. In the inshore zone, wave activity is low, turbidity is high, and the shallow waters host mangroves (mainly *Rhizophora mangle*) and seagrass beds (*Thalassia testudinum*); these two communities develop mainly along the lea shores of the keys and in sandy sediments near the mouths of ocean inlets and in the internal lagoons. The seagrass ecosystem of *T. testudinum* is well represented in submerged areas of the park where extensive monospecific beds of this species and associated algae are found (Bone *et al*. 1998, 2001).
Since 1974, the park has been subject to intense tourism, which greatly stresses the coral reefs. In January 1996, due to a combination of atmospheric and oceanographic phenomena (anomalous upwelling, large river outputs, very calm seas, and low wind speeds), there was a mass mortality of many of the reef and seagrass communities in the park which left less than 1% of living massive coral cover at Playa Caimán, one of the most important reefs (Villamizar 2000, Laboy *et al*. 2001). The recovery

of the seagrass community at one location (Las Luisas) was followed by Klein and Cruz (1998) who found that, after an impressive colonization by the gastropod *Bittium varium*, the whole community returned to its normal composition after 6 months. In December 1999, heavy rainfall throughout the central and western coasts of Venezuela also caused severe damage; salinities within the park decreased to 6‰, this time causing mass mortalities of fish and invertebrates (Bone & Spiniello 2000).

At present, the park is still being used for recreational purposes, but efforts are underway to preserve it and to carry out scientific research with the goal of conservation and the protection of its biological diversity along with sustainable use. This will involve cooperation at both the national (Oceanology program) and international (CARICOMP program) level.

The CARICOMP network (Caribbean Coastal Marine Productivity Program) was established in 1990 by 16 Caribbean countries to conduct standardized, synoptic measurements of the structure, productivity and associated physical parameters of relatively undisturbed coral reefs, seagrasses, and mangroves. In Venezuela, the CARICOMP protocol has been carried out since 1993 at 2 sites: in Margarita island, by EDIMAR (Estación de Investigaciones Marinas, Fundación La Salle de Ciencias Naturales), and in Morrocoy National Park, by INTECMAR (Institute of Technology and Marine Sciences) (CARICOMP 1997, Bone *et al*. 2001).

The Morrocoy National Park Agenda (an integrated study of the Morrocoy National Park system with considerations on the development of plans for its management and sustainable use) is a multidisciplinary and inter-institutional research project involving about 25 Venezuelan scientists from the Universidad Central de Venezuela, Universidad Simón Bolívar, Universidad Nacional Experimental Francisco de Miranda, and FONAIAP-CATIE (now INIA, the National Institute of Agropecuary Research). The main objective of the Morrocoy Agenda is to evaluate the degree of alteration, disturbance, and pollution in the different marine environments of the Park through a coordinated study that integrates all of the components of the ecosystems there. The new data will be compared with previous information in order to discover what might have determined the present condition of the system. This project started in January 2000 and is now in its third and last year. There are 16 themes, grouped within three subprograms:

Physical: environmental parameters, water quality, hydrodynamics, geomorphology, and pollutant transport;

Biological: coastal marine communities (plankton, macroalgae, seagrasses, mangroves, coral reefs, fish, and invertebrates);

Social: the carrying capacity for tourism and artisanal fisheries.

The ultimate goal of this Agenda is to define an environmental reference baseline for the Park that will serve as a basis for the development of plans for its sustainable use, organization, and management, and to formulate a contingency plan for an early warning system capable of rapidly mobilizing the scientific community in the event of a major environmental emergency.

The results of the Morrocoy Agenda are yet to be published in scientific journals, but there are several technical reports available that include extensive lists of the species, genera, and families of flora (phytoplankton, macroalgae, seagrasses) and fauna (zooplankton, invertebrates, and fish) found in the different ecosystems of the Park and demonstrate the impressive diversity of its biota (Bone & Spiniello 2000).

An analysis of venezuelan publications in the marine sciences

Research on the marine environment in Venezuela increased significantly after 1958 following the creation of the Instituto Oceanográfico de Venezuela (Oceanographic Institute of Venezuela) at the Universidad de Oriente (Sucre State), and the Facultad de Ciencias (Faculty of Sciences) of the Universidad Central de Venezuela. The products of this work have been compiled in bibliographical lists, elaborated for several areas of marine science. At least 12 lists detailing different areas, environments, and taxonomic groups have been made available since 1964. The most recent list, published by INTECMAR (Universidad Simón Bolívar), was a compilation of the literature relating to marine sciences and biodiversity (Martín & Díaz 2000). It cites a total of 7490 references covering a period of 42 years (from 1958 to 2000) and includes scientific papers in national and international journals, abstracts of scientific meetings, books, technical reports, and undergraduate and graduate theses. The ecosystems most thoroughly studied, according to Martín & Díaz (2000), are coastal lagoons, mangrove forests and seagrasses. The main topics were biology and ecology, and the taxonomic groups that received more attention were the crustaceans among the invertebrates and the fish among the vertebrates (Table I, Fig. 2).

TABLE I. The main publications, ecosystems, taxonomic groups and institutes involved in marine scientific research.

TABLA I. Las principales publicaciones, ecosistemas, grupos taxonómicos e institutos involucrados en investigaciones científicas marinas.

Type of publication	Congress abstract 41.0%	Paper in scientific journal 29.5%	Undergraduate and graduate thesis 15.7%	Technical reports 3.9%	Chapter in book 3.7%	Books 3.3%
Ecosystem studied	Coastal lagoons 11.5%	Mangrove forests 4.1%	Seagrasses 3.7%	Coral reefs 1.4%	Sandy beaches 1.1%	Rocky shores 0.5%
Taxonomic group Vertebrates	Fishes 87.9%	Reptiles 6.7%	Birds and mammals 5.9%			
Taxonomic group Invertebrates	Crustaceans 37.0%	Mollusks 36.6%	Cnidarians 7.6%	Echinoderms 4.6%		
Institution	UDO 56.3%	USB 11.4%	UCV 10.1%	IVIC 6.0%	FLASA 5.1%	LUZ 2.8%

UDO: Universidad de Oriente
UCV: Universidad Central de Venezuela
USB: Universidad Simón Bolívar
LUZ: Universidad del Zulia
FLASA: Fundación La Salle de Ciencias Naturales
IVIC: Instituto Venezolano de Investigaciones Científicas

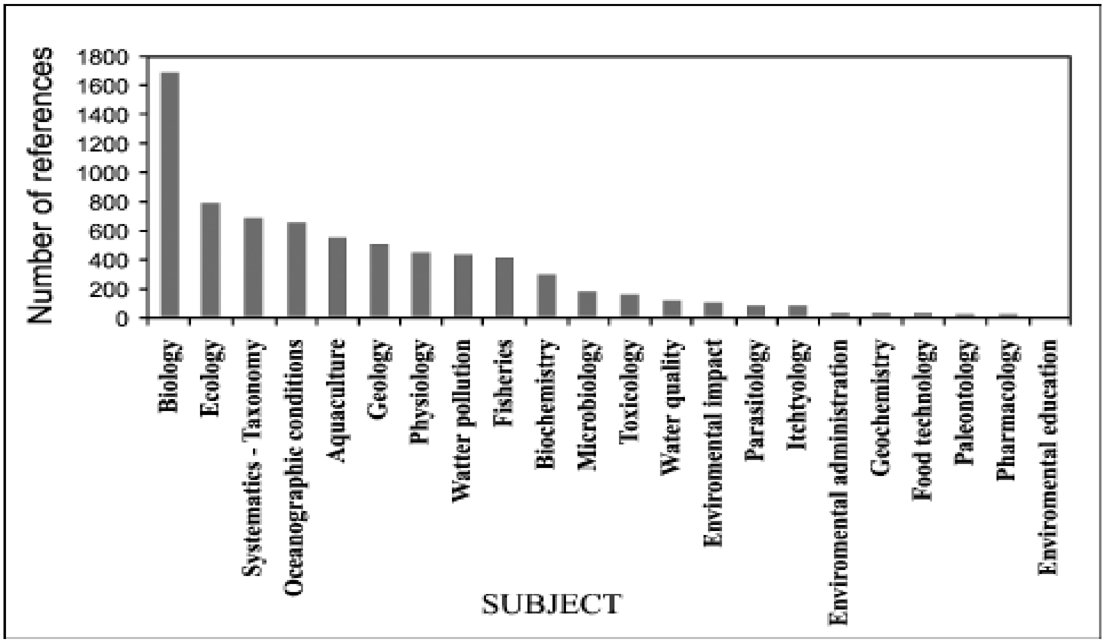

FIGURE 2. The number of publications between 1958 and 2000 in the different areas of marine science (Data from Martín & Díaz 2000).

FIGURA 2. Número de publicaciones entre 1958 y 2000 en las distintas áreas de las ciencias marinas. (Información de Martín & Díaz 2000).

TABLE II. Numbers of documents, concerning aspects of marine science in Venezuela, which appeared in the decades from 1940 to 1990 (Martín & Díaz 2000).

TABLA II. Número de documentos respecto a los aspectos de la ciencia marina en Venezuela, entre las décadas de 1940 a 1990 (Martín & Díaz 2000).

Decade	Number of total publications (*)	Number of papers and books
1940-1949	45	43
1950-1959	79	59
1960-1969	448	331
1970-1979	1102	547
1980-1989	2605	781
1990-1999	3006	690

* Includes published books and papers, as well as unpublished “gray literature” (thesis, technical reports, and unpublished monographs)

In the last six decades, the number of publications in the marine sciences in Venezuela has increased significantly (Table II), demonstrating the remarkable increase in the knowledge of this field and the commitment of Venezuelan researchers to their work.

(2) COASTAL AND MARINE PROTECTED AREAS OF VENEZUELA

Historical background and general considerations.

Protected areas (PAs), as considered in this paper (Fig.1), are those whose primary objective is the protection of ecosystem or biotic resources. Accord with this, out of the ABRAE categories, only the National Parks, Natural Monuments, Wildlife Refuges, and Wildlife Reserves (MARNR 1985) will be referred to as PAs and these correspond to the IUCN (1994) categories as indicated in Table III.

- National Parks (República de Venezuela 1966) aim to maintain ecosystems and scenic resources as pristine as possible, though accepting some degree of human intervention for recreational purposes, non-industrial fisheries, and other forms of "sustainable use", according to a zoning and management plan.
- Natural Monuments (República de Venezuela 1966) aim to preserve relevant physical features, but within a framework of ecosystem and biotic resources protection, functioning, in fact, as small national parks that, depending upon the specific management plans and zoning, might be even more strictly controlled than National Parks.
- Wildlife Refuges (República de Venezuela 1970) have as a primary goal the preservation of faunal populations. Historically, these programs have focused on migratory vertebrates (i.e. sea turtles and birds) and their habitats, but legally, they include all biotic resources.
- Wildlife Reserves (República de Venezuela 1970) have, as a primary objective, the sustainable use of faunal resources, including sport hunting and fishing.

The first PAs established specifically to conserve marine ecosystems were Archipiélago Los Roques National Park and Isla de Aves Wildlife Refuge in 1972. Politically, this was regarded as a commitment by Venezuela to conserve marine ecosystems, honoring the second World Conference on National Parks held in Yellowstone in 1972 (see Amend 1992). To date, Venezuela has designated 21 PAs that include, partially or totally, coastal and marine ecosystems; three of them are parts of Lake Maracaibo.

REPRESENTATION OF COASTAL AND MARINE PROTECTED AREAS

Venezuela has legal rights or sovereignty over approximately 900,000 km² of marine environment (MARN 2000). PAs represent only 0.6% of this (5,470 km², Table III), relatively little in comparison with the nearly 15% (142,306 km²) occupied by the continental PAs (MARN 2000). However, in terms of ecosystem protection, the difference is exaggerated because most of the maritime area is ocean, the Venezuelan continental shelf covering about 100,000 km².

Coastal PAs incorporate 18.2% (682 km, Table II) of the 3,964 km of Venezuelan continental coastline and almost all of the major reef ecosystems are included and protected within them. Two PAs alone, Los Roques and Isla de Aves, comprise 68.7% (3,758 km²) of the protected marine space, a reflection of the great importance they have in quantitative terms, and these two represent the nucleus of the Venezuelan marine PAs system. From another perspective, however, strictly marine areas (see Table III) comprise only 3.84% of the total PAs of Venezuela, indicating a strong bias towards the mainland.

All Venezuelan coastal and marine PAs are in the central Caribbean marine ecoregion (IUCN 1994), which is ranked as being of the highest priority for conservation among the coastal biogeographical provinces of Latin America and the wider Caribbean (Sullivan & Bustamante 1999). The extent to which these PAs include representative regions of coastal and marine biodiversity in Venezuela is still not clear.

Threats and levels of risk in coastal and Marine Protected Areas

A number of significant threats to these PAs are listed in Table III; it is clear that coastal and marine areas are under pressure. The level of risk faced by the National Parks and Natural Monuments of Venezuela was recently assessed (Rivero Blanco *et al.* 2001). Risk was considered to be the degree to which an area is prone to reach a high level of deterioration, given the intrinsic sensitivity of and the pressures exerted on each PA. The results of this work indicate that 7 of the 43 National Parks in Venezuela have a risk level of >80 (on a scale of 0-100), 4 of these being in the coastal-marine category - Mochima, Morrocoy, San Esteban, and the Península de Paria, in decreasing order of risk. The lowest level among the coastal-marine parks is held by Archipiélago Los Roques, with a rating of 60, the rest having risk levels between 60 and 80. On the other hand, only two coastal-marine Natural Monuments have ratings around 60, the Laguna de Las Marites and the Tetas de María Guevara (Nueva Esparta State), which rank eighth and eleventh out of 21 Natural Monuments. A similar analysis remains to be conducted for Wildlife Reserves and Refuges, but the results are not expected to be significantly different from those for the National Parks.

Management

There is no doubt that the management of the coastal and marine areas is the most demanding and difficult of all the PAs in Venezuela. All of them are subject to impacts coming from outside their legal boundaries and, thus, beyond the reach of the administrative agency, INPARQUES (Instituto Nacional de Parques), responsible for PAs management and law enforcement. Little or no coordination between central government agencies and state and local government makes it difficult to resolve or diminish the effects of these impacts. Little attention is paid politically to coastal and marine environmental problems. Twelve of these PA have adequate management zoning and management plans, but real management effectiveness is more dependent on issues beyond formal planning. Institutional strength and professional capability are the most urgent needs of the PAs management agencies. Public support for strong management is even more necessary, in addition to the significant involvement of universities and non-governmental organizations (NGOs) in research, monitoring, and assisting with specific resource management. Morrocoy, Cuare, and now the Orinoco Delta are good examples of such involvement.

(3) Biological collections

The collections of preserved and living animals and plants represent powerful means for conserving, ex situ, biodiversity. Herbariums and zoological collections exist, in the main, for species identification and to make this type of information available to the general public in the form of a database. Venezuela has 25 herbariums (15 of them registered in the Index Herbarium) which contain 626,000 specimens and 5,494 "types". There are also zoological museums and collections with a total of 2,080,000 vertebrate specimens and about 3,000,000 specimens of invertebrates as well as 59 "types". The 10 botanical gardens and 18 zoos with living specimens need to be improved to properly function as centers for the conservation of biodiversity (Aguilera 2000). The most important collections of marine fauna in Venezuela are on Margarita Island at the Museo Marino de Margarita, and in the Fundación La Salle de Ciencias Naturales, Caracas and Margarita Island and the Museo de Ciencias Biológicas, UCV, Caracas.

The outcome of a workshop on zoological diversity Guanare city (Portuguesa State) in 1999, where more than 30 Venezuelan researchers participated, will be published in Acta Biológica Venezuelica by the end of 2003. It consists basically of a list of species, genera, and families of each major phylum. From this workshop, the diversity of marine invertebrates reported in Venezuela is made up of about 558 families, 1,382 genera, and 2,697 species as specified in Table IV; this is considered to be highly underestimated.

TABLE III. The marine protected areas in Venezuela: area, ecosystems, management plans and significant threats.

TABLA III. Areas marinas protegidos en Venezuela: área, ecosistemas, planes de manejo y amenazas significantes.

Name * (State)	**IUCN Category [1] (Ramsar Site) [10]**	**Total area[2] (km^2)**	**Marine area [3] (km^2)**	**Islands area [4] (km^2)**	**Continental coast line [5] (km)**	**Marine and coastal habitat types present [6,7] Ecosystems**	**Year of legal designation [8] (Management plan) [8]**	**Significant Threats [9]**
Ciénagas del Catatumbo (NP) (Zulia)	II	2500.00	159.2 (lake area)	——	90.1 (lake coast)	Estuarine: Flooded savannas Flooded forests (freshwaters)	1991 (——)	Poaching and overfishing. Oil spills by terrorist activities. Pollution from oil production and transport systems.
Ciénagas de Juán Manuel de Aguas Blancas y Aguas Negras (WRs) (Zulia)	VI	706.80	104 (lake area)	——	56 (lake coast)	Estuarine: Flooded savannas Flooded forests (freshwaters) Interconnected with Ciénagas del Catatumbo	1975 (——)	Poaching and overfishing. Oil spills by terrorist activities. Pollution from oil production and transport systems.
Ciénaga La Palmita e Isla de Pájaros (WRs) (Zulia)	VI	25.26			NA (lake coast)	Coastal lagoon: Mangroves Sandy beaches (estuarine brackish waters)	2000 (——)	Pollution from oil production and transport systems.
Ciénaga de Los Olivitos (WRf) (Zulia and Falcón)	IV (1996)	222.04	65	4.6	44	Coastal lagoon: Mangroves Sandy and muddy beaches	1986 (2001)	Poaching and overfishing. Impacts from industrial salt production systems.

Continuación Tabla III

Name* (State)	**IUCN Category**[1] **(Ramsar Site)**[10]	**Total area**[2] **(km^2)**	**Marine area**[3] **(km^2)**	**Islands area**[4] **(km^2)**	**Continental coast line**[5] **(km)**	**Marine and coastal habitat types present**[6, 7] **Ecosystems**	**Year of legal designation**[8] **(Management plan)**[8]	**Significant Threats**[9]
						(estuarine brackish waters)		
Boca de Caño (WRf) (Falcón)	IV	4.53	——	——	——	Coastal lagoon: Sandy beaches Mangroves	1989 (——)	Impacts from adjacent tourism developments. Mangrove extraction.
Médanos de Coro (NP) (Falcón)	II	912.80	598.80	——	96.8	Flat sandy coast: Sandy beaches Mangroves Soft bottoms	1974 (1995)	Pollution from marine transportation systems. Impacts from human settlements.
Tucurere (WRs) (Falcón)	VI	178.00	NA	NA	NA	Estuarine coastal lagoon: Sandy beaches Mangroves	2001 (——)	Poaching and overfishing. Impacts from human settlements.
Cuare (WRf) (Falcón)	IV (1988 only 84% of total area)	118.53	18.92	NA	24	Coastal lagoon: Seagrasses Mangroves Sandy beaches Rocky shores Coral reefs Soft bottoms	1972 (1993)	Impacts from adjacent tourism developments. Impacts from human settlements. Impacts from adjacent tourism developments.
Morrocoy	II	320.90	205.00	42.00	101.0	Coral keys system:	1975	Recreational activities.

Continuación Tabla III

Name * (State)	**IUCN Category** [1] **(Ramsar Site)** [10]	**Total area**[2] **(km²)**	**Marine area** [3] **(km²)**	**Islands area** [4] **(km²)**	**Continental coast line** [5] **(km)**	**Marine and coastal habitat types present** [6, 7] **Ecosystems**	**Year of legal designation** [8] **(Management plan)** [8]	**Significant Threats** [9]
(NP) **(Falcón)**						Sandy beaches Rocky shores Seagrasses Coral reefs Mangroves Soft bottoms Interconnected with Cuare	(1995)	Pollution from marine transportation and industrial systems. Sedimentation from the upper watersheds.
San Esteban (NP) **(Carabobo)**	II	435.00	36.25	0.88	22.0 56.0	Coral keys system: Sandy beaches Rocky shores Seagrasses Coral reefs Mangroves Coastal lagoons Soft bottoms	1987 (1996)	Pollution from marine transportation systems. Sedimentation from the upper watersheds. Impacts from human settlements.
Henri Pittier **(NP)** **(Aragua)**	II	1078.00	——	——		Steep coast: Rocky shores Seagrasses Coral reefs Mangroves Sandy beaches	1937 (1995)	Recreational and naval activities Impacts from human settlements. Poaching and overfishing.
Archipiélago Los	II	2211.20	2178.35	32.85		Coral keys system:	1972	Recreational activities

Continuación Tabla III

Name * (State)	**IUCN Category [1] (Ramsar Site) [10]**	**Total area [2] (km^2)**	**Marine area [3] (km^2)**	**Islands area [4] (km^2)**	**Continental coast line [5] (km)**	**Marine and coastal habitat types present [6, 7] Ecosystems**	**Year of legal designation [8] (Management plan) [8]**	**Significant Threats [9]**
Roques (NP) (Federal Dependencies)	(1996)			All emerged areas	——	Sandy beaches, rocky shores, seagrasses, coral reefs, mangroves, soft bottoms	(1991)	Impacts from human settlements Poaching and overfishing.
Laguna de Tacarigua (NP) (Miranda)	II (1996)	391.00	207.00	——	23.0	Coastal lagoon: Sandy beaches Mangroves Soft bottoms	1974 (1991)	Sedimentation from the upper watersheds. Impacts from human settlements Poaching and overfishing
Mochima (NP) (Sucre and Federal Dependencies)	II	949.35	491.70	42.87	104.7	Steep coast: Sandy beaches Rocky shores Seagrasses Coral reefs Mangroves Soft bottoms Coastal lagoons	1973 (1993)	Recreational activities Impacts from human settlements Sedimentation from the upper watersheds.
Tetas de María Guevara (NM) (Nueva Esparta)	III	16.70	4.0	——	10.0 (insular coast line)	Coastal lagoon: Mangroves Coastal lagoons Sandy beaches	1974 (1995)	Impacts from human settlements Poaching and overfishing. Pollution from marine transportation systems.

Continuación Tabla III

Name * (State)	**IUCN Category [1] (Ramsar Site) [10]**	**Total area[2] (km^2)**	**Marine area [3] (km^2)**	**Islands area [4] (km^2)**	**Continental coast line [5] (km)**	**Marine and coastal habitat types present [6, 7] Ecosystems**	**Year of legal designation [8] (Management plan) [8]**	**Significant Threats [9]**
Laguna de La Restinga (NP) (Nueva Esparta)	II (1996)	171.80	63.64	——	35.0 (insular coast line)	Coastal lagoon: Sandy beaches Coral reefs Rocky shores Mangroves Coastal lagoons Soft bottoms	1974 (1991)	Recreational activities Impacts from human settlements Poaching and overfish-ing.
Laguna de Las Marites (NM) (Nueva Esparta)	III	36.74	0.9	——	4.0 (insular coast line)	Coastal lagoon: Mangroves Soft bottoms	1974 (1993)	Impacts from human settlements Poaching and overfishing.
Península de Paria (NP) (Sucre)	II	375.00	——	1.26	64.0	Steep coast: Rocky shores Mangroves Coastal lagoons	1979 (——)	Impacts from human settlements. Poaching and overfish-ing.
Isla Aves (WRf) (Federal Depen-dencies)	IV	1580.21	1580.17	0.04 Single emerged area	0.7 (insular coast line)	Coral keys sys-tem: Sandy beaches Coral reefs Soft bottoms	1972 (1978, regula-tions only)	Moderate impacts from Navy post.
Turuépano (NP) (Sucre)	II	700.00	20.5	——	46.6	Flat coast: Sandy and muddy beaches Mangroves	1992 (——)	Pollution from maritime transportation Influence of human settlements.

Continuación Tabla III

Name * (State)	**IUCN Category** [1] **(Ramsar Site)** [10]	**Total area** [2] **(km^2)**	**Marine area** [3] **(km^2)**	**Islands area** [4] **(km^2)**	**Continental coast line** [5] **(km)**	**Marine and coastal habitat types present** [6, 7] **Ecosystems**	**Year of legal designation** [8] **(Management plan)** [8]	**Significant Threats** [9]
Delta del Orinoco (NP) (Delta Amacuro)	II	3310.00	——	——	50.0	Coastal lagoons Flooded savannas ***Flooded forests*** River Delta: Sandy and muddy beaches Mangroves Flooded savannas ***Flooded forests*** (estuarine brackish waters)	1992 (——)	Pollution from maritime transportation Poaching and overfishing
TOTAL		16243.86	5733.43 (5470,23 strictly marine)	124.5	827.9 (681.8 strictly marine)			

Notes:
*: NP=National Park, NM=Natural Monuent, WRf=Wildlife Refuge, WRs=Wildlife Reserve

1: Protected Areas categories applying IUCN(1994) criteria: II=managed mainly for ecosystem protection and recreation; III= managed mainly for conservation of specific natural features; IV= managed mainly for conservation through management intervention; VI= managed mainly for the sustainable use of natural ecosystems.

2: Inparques (Venezuelan National Parks Service) and MARN (Biological Diversity National Office)
3: Luis Romero (INPARQUES), Vicente Vera (MARN), Jorge Padrón. Predominantly marine, except where indicated between parenthesis (-).
4: Luis Romero (INPARQUES), Vicente Vera (MARN).
5: Continental sea shore line. Edgard Yerena. Rolando Vera. Predominantly marine, except where indicated between parenthesis (-).
6: Names according to Penchaszadeh et al. (2000) Names in italics translated from Rodriguez-Altamiranda (1999). “Muddy beaches”, according to Cowardin *et al* (1979). “Soft bottoms”, according to Miloslavich (pers. com), refered only to soft bottoms habitats at open sea. Predominantly marine waters, except where indicated between parenthesis (-) and coastal lagoons where conditions are locally variable.
7: Edgard Yerena, Hedelvy Guada, Vicente Vera, Jorge Padrón, Profauna 1998.
8: Year of legal designation as protected area or approval of management plan, as published in Official Gazette. All approved management plans are in force and include regulations. Source: INPARQUES and MARN (Biological Diversity National Office)
9: Three most important threats or sources of threats. Source: For NP and NM: Rivero-Blanco et al (2001); For WRf and WRs: Lentino and Bruni (1994); Vicente Vera (MARN); Edgard Yerena.
10: Year of acceptance as Ramsar Site.
——: Data does not apply to such area.
NA: Data not available

TABLE IV. Estimated diversity of marine invertebrates in Venezuela.

TABLA IV. Diversidad estimada de los invertebrados marinos en Venezuela.

Group	Number of Families	Number of Genera	Number of Species
Porifera	31	55	86
Cnidaria	38	65	108
Platyhelminthes	4	4	6
Nemertina	1	1	1
Rotifera	6	8	14
Nematoda	28	79	166
Annelida	47	158	287
Mollusca	185	395	815
Sipuncula	3	7	14
Crustacea	161	498	1024
Chelicerata (Pycnogonida)	4	10	10
Chaetognatha	1	3	12
Echinodermata	42	85	139
Urochordata	6	13	14
Cephalocordata	1	1	1
TOTAL	**558**	**1382**	**2697**

(4) THE LEGAL INSTITUTIONAL FRAMEWORK IN THE COUNTRY

One of the first steps taken in Venezuela towards an environmental policy aimed at the conservation of ecosystems and pristine areas and the preservation of biological diversity was the setting-up, in 1973, of INPARQUES. However, it was in 1976 that a formal environmental policy was initiated with the promulgation of the Organic Law of the Environment (June 7, 1976) and the Organic Law of Central Administration (December 28, 1976). This led to the creation of the Ministry of Environment and Natural Renewable Resources (MARNR) and was the institutional response of the State to the need to reconcile the physical demands of economic growth and development with the sustainable use of renewable natural resources. Its strategic goals are the conservation, defense, and improvement of the environment.

Venezuela actively participated in the 1992 Nairobi Convention for the establishment of Agenda 21 and in the elaboration of the Agreement on Biological Diversity itself, which was signed at the Convention on Biological Diversity at The Earth Summit (the United Nations conference about Environment and Development) held in Rio de Janeiro, Brasil, in 1992. This commitment was supported by an Approving Law on September 12, 1994. This committed Venezuela to formulate strategies, plans, and programs aimed at the conservation and sustainable use of the biota and its diversity and to incorporate them into the country's future schemes. The new Venezuelan constitution, approved in December 15, 1999, estipulates in Article 127 as an obligation of the State, the protection of the environment, biological and genetic diversity, ecological processes, and the areas of special ecological importance. Finally, on May 24, 2000, the Law on Biological Diversity was signed and the National Office of Biological Diversity (Oficina Nacional de Diversidad Biológica, ONDB) was established in the now MARN, which replaced the former MARNR to develop a national strategy in biodiversity.

THE NATIONAL STRATEGY IN BIOLOGICAL DIVERSITY AND PLAN OF ACTION

The National Strategy in Biological Diversity was undertaken by MARN and ONDB. The project started in 1997 with the first stage, an assessment of the status of biological diversity in Venezuela, supported financially by the Global Environmental Fund (GEF) through the United Nations Program for Development (UNPD). There were 3 themes: state of knowledge, conservation, and sustainable use. Following this, MARN organized several workshops and then presented a National Strategy with a clear mission: "the State will promote the necessary actions to increase knowledge, ensure the conservation and the sustainable use of Biological Diversity, and incorporate these actions into the national, regional, and municipal development plans. To carry out the proposed objectives, national and international strategic alliances will be established".

The general objectives of the National Strategy are:

• To establish actions to increase knowledge about biological diversity at the ecosystem and community level, about wild and domestic species, about genetic resources and about environmental services.

• To establish the necessary actions to ensure the conservation of biological diversity, taking into account their importance, strategic character, economic value, and significance for accomplishing the sustainable use of the country's resources.

• To promote programs for the sustainable use of biological resources;

• To contribute with the active participation of the local and indigenous populations in the conservation and sustainable use of biological resources.

• To promote the divulgation of and create awareness in society about the importance of biological diversity.

• To prevent, mitigate, and restore any damage caused to the ecosystems by economic activities such as mining, oil activities, fisheries, farming, forestry, tourism, urban and industrial development.

• To prevent and control the introduction of invasive exotic species to the different ecosystems in the country.

• To promote the outreach of biotechnologies that will allow the sustainable use of the biological resources, properly regulating access to the genetic wealth of the country.

• To prevent and control the risks derived from the use of genetically modified living organisms.

• To promote the concepts of ecosystem focus and bioregional planning in the development of the country.

• To promote the participation of society at large in the conservation, management, and dissemination of knowledge of biological diversity.

• To fulfill the commitments acquired by signing the Treaty of Biological Diversity and other agreements.

• To achieve a fair and equitable national participation in the benefits produced by the access to genetic resources.

Following meetings, workshops, and other discussions, 15 projects or lines of research were established as the National Strategy:

1. The valuation and dissemination of information about biological diversity.
2. The promotion of conservation *in situ*.
3. The promotion of conservation *ex situ*.
4. The assurance and promotion of the participation of society in the management of biological resources and their diversity.
5. The incorporation of knowledge about biological diversity in formal and informal education and the training of human resources.
6. The involvement of local and indigenous communities in the management of biological resources.
7. The prevention, mitigation, and control of the impact of human activities on biological diversity.
8. The promotion of the sustainable use of biological resources.
9. The establishment of mechanisms regulating access to genetic resources.
10. The development of biotechnologies for aiding the sustainable use of biological resources.
11. The strengthening of international, regional and subregional cooperation.
12. The strengthening of the institutions dedicated to the conservation of biological diversity and of conducting the National Strategy.
13. The promotion of funding for the National Strategy on biological diversity.
14. The development of programs to fulfill international commitments within the framework of the Treaty of Biological Diversity.

15. The development of other programs of national priority.

Item 14 includes several programs relevant to the marine environment: (1) the conservation of the wetland ecosystems and their biodiversity; (2) the use and carrying capacity of the ecosystems for tourist activities; (3) the prevention and control of exotic invasive species; and (4) the conservation and sustainable use of coral reefs. Among the projects developed in Item 15, the most important is the conservation of biodiversity and the sustainable use of biological resources in marine coastal and insular areas.

Other initiatives related to the conservation of biological diversity

Venezuela has also been an active participant in non-governmental organizations (NGOs) on the subject of biological diversity, being the sole Latin American country participating as a founder of the UICN and the first Latin American State to request membership. One of the most important recent contributions to the subject was the workshop, "Management in the Venezuelan NGOs involved with the Conservation of Biological Diversity", held in Caracas in June, 1996 and organized by Fundación Polar, the Venezuelan Association for the Conservation of Natural Areas (ACOANA) and the Interamerican Center for the Development of and Research on the Territorial Environmental (CIDIAT). Notable themes included: the management of natural resources, environmental education, the management of protected areas, research and monitoring, ecosystem recovery, and threatened species. All of these projects are being carried out thanks to the support, coordination, and direction of the NGOs, particularly FUDENA, PROVITA, and Econatura in the marine areas.

CONCLUSIONS: THE UNKNOWN

This paper has documented the information available in Venezuela regarding scientific research in biodiversity, the different ecosystems, and degree of knowledge that has been generated, the importance and extent of the PAs as biodiversity reserves, and the legal institutional framework aimed at their protection and sustainable use.

Further ecological and biogeographical studies are needed in order to determine in more detail the biodiversity in the marine PAs. More PAs will probably be needed to reach an adequate representation of the biodiversity of all of the ecosystems. The risk levels faced by PAs are high and management effectiveness is poor. Stronger support of PA agencies, local governments, scientific institutions, and NGOs is needed in order to reverse this situation.

Table V summarizes, within the main objectives of the Concepción Census of Marine Life South America workshop, what is known on a local scale, what we want to know on a broader scale, and ideas for new integrated projects concerned with the marine ecosystems and their associated biodiversity. In the short term (10 years), priorities are the estimation of the areas of and the completion of species lists and health status assessments for the main ecosystems. The resulting information must be compiled and summarized in nationwide Geographic Information Systems (GIS) databases, accessible to both the scientific community and the management agencies. In the longer term, a genetic inventory will also be required in order to provide more detailed knowledge of the biological resources. In both cases, the training of human resources in taxonomy, systematic; and techniques in molecular biology is necessary.

ACKNOWLEDGMENTS

We wish to thank Geog. Rolando Vera for the design of the map and Geog. Vicente Vera for helping with the compilation of the maps used for Figure 1. We are also indebted to Dr. Víctor Ariel Gallardo, Centro de Investigaciones Oceanográficas en el Pacífico Sur-Oriental (COPAS), Universidad de Concepción, Chile, for his invaluable help in promoting the First South American Workshop on Marine Biodiversity, and the sponsors of this workshop, Dr. Shuha Sathyendranath (POGO), Dr. Ronald O'Dor (Census of Marine Life) and Dr. Jesse Ausebel (Sloan Foundation). This work was partially supported by a Decanato de Investigación y Desarrollo, Universidad Simón Bolívar grants to the Grupo de Ciencias Marinas.

TABLE V. Current knowledge and research needs for the marine ecosystems in Venezuela.

TABLA V. Conocimientos actuales y necesidades para la investigación de los ecosistemas marinos en Venezuela.

Ecosystem	**Area**	**What we know**	**What we need to know 10 year program**	**What we need to know Beyond 10 year program**
Sandy Beaches	?	Species list, trophic structure (few), population studies (few), reproductive biology of mollusks	GIS: area, physical characteristics, production and associated fauna	Dynamics of the biological communities, energy/ matter fluxes
Rocky Shores	?	Local horizontal zonation, macroalgae species list	GIS: area, horizontal and vertical zonation, associated species, temporal variability.	Dynamics of the biological communities, energy/ mater fluxes. Interactions between hydrodynamics and communities
Sea grasses	? (Morrocoy 373 has)	Species list of associated fauna (few local), production and productivity, biomass, demographic studies (local, few)	GIS: area, physical characteristics, production and associated fauna. Human impacts	Interaction with other ecosystems, with genetic and energetic flow
Coral reefs	? (Los Roques 150,000 has) (Las Aves 30,000 has)	Species List (corals, fishes, macro-invertebrates). Health status (local). Coral cover (local). Coral and fish community structure (local)	GIS: area, health status, and species cover. Epidemiological approach to coral diseases. Impacts (fisheries, tourism), population interconnections, influence area studies (Hinterland approach)	Consolidate Caribbean wide studies. Genetic studies
Mangroves	300,000 has	Area, species composition, uses, associated	GIS: area, vertical zonation (sediment, roots and canopy)	

Continuación Tabla V.

Ecosystem	Area	What we know	What we need to know 10 year program	What we need to know Beyond 10 year program
		fauna (birds, terrestrial and marine), legislation		
Coastal Lagoons	673,700 has	Area, species list (local)	GIS: area, species composition, circulation dynamics. Impacts (fisheries, aquaculture, tourism)	Hydrodynamics and community interactions.
Orinoco Delta	3,000,000 has	Area, fish community composition in the southern delta. Cover of mangrove forest and mangrove species composition. Limited knowledge of indigenous use of local flora and fauna	GIS: physical characteristics. Complete species inventory and community structure	Integrated programs for sustainable use of the ecosystems
Non-vegetated soft bottoms	?	Species list (incomplete and local)	GIS: area, physical characteristics, production and associated fauna Updated inventory list, natural barriers	Sustained monitoring of bottom communities. Continental shelf
Pelagic realms	90,000,000 has	General oceanographic characteristics (outdated), upwelling dynamics, fisheries (industrial, artisan), fish species list	GIS More remote sensing capabilities. Circulation measurements. Plankton dynamics (horizontal, vertical and temporal)	Sustained monitoring program of deep sea research (beyond continental shelf). Species lists and habitat characterization

Possible future projects: local, regional and global

Local (Venezuela)

- Charting and the production of maps (Geographical Information Systems) of key coastline and island ecosystems, the extent and status of each of them. Comparison of systems and of biodiversity. Crosslink between floral and faunal inventories.
- Integration of the information about local ecosystems.
- Elaboration of a biodiversity database.

Regional (Southern Caribbean: Colombia, Venezuela, and the Netherlands Antilles)

- Upwelling zones
- Natural barriers (rivers)
- Global (South America)
- Pacific-Atlantic north-south gradients of sandy and rocky ecosystems
- Comparative studies of estuarine and deltaic systems

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Fecha de recepción: 05/05/03
Fecha de aceptación: 101/09/03