Coral Reef Conservation in the Eastern Tropical Pacific

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Juan José Alvarado, Octavio Aburto-Oropeza, Rubén Abad, Enrique Barraza, Margarita Brandt, Jaime Cantera, Priscila Estrada, Carlos F. Gaymer, Ana Gloria Guzmán-Mora, James J. Herlan, and Juan L. Maté

Abstract

This chapter reviews and evaluates coral reef conservation strategies along the eastern tropical Pacific (ETP), a narrow biogeographic region on the Pacific American coast that extends from southern Baja California, Mexico to northern Peru, including several oceanic islands. The ETP is a natural laboratory, a model for understanding the development of coral biotopes in a changing environment. We evaluate conservation strategies in seven countries in the ETP region (Peru was not included for apparent lack of coral habitats). A survey of current Marine Protected Areas (MPAs) highlights great variation in the number, scale and management approaches. Generally, MPAs with no-take areas are relatively uncommon, with multi-purpose areas favored. The Cabo Pulmo MPA in Baja California, Mexico demonstrates that when a local community is involved in the creation and enforcement measures of an MPA, conservation success can be achieved. Despite such apparent

J.J. Alvarado (✉)
Centro de Investigación en Ciencias del Mar y Limnología, Escuela de Biología, Universidad de Costa Rica, 2060-1000 San José, Costa Rica
e-mail: juan.alvarado@ucr.ac.cr

O. Aburto-Oropeza · P. Estrada
Marine Biology Research Division, Scripps Institution of Oceanography, 9500Gilman Drive, La Jolla, CA 92093, USA
e-mail: maburto@ucsd.edu

P. Estrada
e-mail: priscilaep@yahoo.com.mx

R. Abad
Museo de Zoología QCAZ, Sección Invertebrados, Pontificia Universidad Católica del Ecuador, Quito, Ecuador
e-mail: rdabad90@hotmail.com

E. Barraza
Ministerio de Medio Ambiente y Recursos Naturales, Col. y Calle Las Mercedes, San Salvador, El Salvador
e-mail: ebarraza@marn.gob.sv

M. Brandt
Colegio de Ciencias Biológicas y Ambientales, Universidad San Francisco de Quito, Diego de Robles s/n y Pampite, Cumbayá, Quito, Ecuador
e-mail: mbrandt@usfq.edu.ec

J. Cantera
Departamento de Biología, Universidad del Valle, Calle 100, No 13-00Cali, Colombia
e-mail: jaime.cantera@correounivalle.edu.co

Carlos F.Gaymer
Departamento de Biología Marina, Millennium Nucleus for Ecology and Sustainable Management of Oceanic Islands (ESMOI) and Centro de Estudios Avanzados en Zonas Áridas (CEAZA), Universidad Católica del Norte, Larrondo 1281, Coquimbo, Chile
e-mail: cgaymer@ucn.cl

Ana GloriaGuzmán-Mora
Marine Program, Conservation International-Costa Rica, Los Yoses, 2365 2050 San Pedro, Costa Rica
e-mail: aguzman@conservation.org

J.J. Herlan
Millennium Nucleus for Ecology and Sustainable Management of Oceanic Islands (ESMOI), Departamento de Biología Marina, Universidad Católica del Norte, Larrondo 1281, Coquimbo, Chile
e-mail: jherlan@ucn.cl

Juan L.Maté
Smithsonian Tropical Research Institute, Balboa, Apartado Postal 0843-03092 Ancón, Republic of Panamá
e-mail: matej@si.edu

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successes, inadequate and confusing legal practices have generally forestalled effective protection of coral ecosystems in the ETP. However, in several instances nongovernmental organizations (NGOs) have assisted with planning, negotiation and stakeholder engagement. Nonetheless these findings underscore how the establishment of an MPA does not guarantee that conservation goals will be achieved. This calls for a new approach that incorporates contributions from ecological studies along with a high investment in capacity development and training to ensure that the goals of MPAs better complement effective fisheries and ecosystem management within and outside their borders.

Keywords
No-take areas • Paper parks • Fisheries management • Seascape • Latin American reefs

21.1 Introduction

Coral reefs are considered to be one of the most diverse ecosystems globally, even when compared with tropical rain forests (Reaka-Kudla 1997; Stella et al. 2011). Coral reefs are valuable natural resources that support a vast biodiversity, and are of immense value to society—biologically, culturally and economically (Spurgeon 1992; Pendleton 1995; Moberg and Folke 1999; Brander et al. 2007). In addition to wetlands, mangroves and tropical forests, coral reefs have been identified as one of Planet Earth's four chief biomes with the highest values or services. While the monetary value of coral reef environments is calculated to be 352,249 US$ $ha^{-1}year^{-1}$ (de Groot et al. 2012), there is still widespread neglect of this ecosystem with an increase in disturbances globally (Wilkinson 2006; Hoegh-Guldberg 2014) that affect their diversity and services (Andersson 2007; Carpenter et al. 2008).

In order to preserve coral reefs, four main strategies have been adopted: (1) *ex situ* protection (i.e. aquariums), (2) the establishment of Marine Protected Areas (MPAs), (3) the implementation of management tools, and (4) enforcement activities. MPAs are patches in the marine environment, allocated for the protection of biodiversity, the management of fisheries, and for research, all activities that can generate recreational, economic, aesthetic and educational benefits (Hoyt 2005; Edgar et al. 2007). The establishment of MPAs is to assure the permanence of the spectrum of marine biodiversity, from the genetic variability of individuals and populations to ecosystems, thereby providing goods and services for future generations (Lubchenco et al. 2003). Globally, only 18.7 % of coral reefs are under MPA status. Of this number, most allow multi-purpose activities (12 %), 5.3 % extractive uses, and only 1.4 % includes 'no-take' areas (Mora et al. 2006). In Latin America and the Caribbean, there are approximately 760 MPAs (of which 13 % are no-take, 76 % take, and 12 % multi-purpose), covering 309,562 km^2 (5 % no-take, 17 % take, 78 % multi-purpose, in terms of total area) (Guarderas et al. 2008). In the ETP, Mora et al. (2006) reported the presence of 24 MPAs with coral habitats, covering 6899 km^2.

Legal tools for protecting coral habitats include national and international initiatives that promote the conservation and effective management of coastal ecosystems and endangered habitats. These include the United Nations Convention on the Law of the Sea (UNCLOS), Agenda 21 (Chaps. 15 and 17) together with the International Coral Reef Initiative (ICRI), the RAMSAR Convention on Wetlands, the Convention on Biological Diversity (CBD), the Convention on International Trade in Endangered Species (CITES), and the UNESCO Convention on the Protection of the World Cultural and Natural Heritage (Davidson 2002, 2006; Zedler and Kercher 2005). The ICRI seeks to implement the best management strategies to conserve the world's coral reef resources (Davidson 2006), however, across the ETP only five countries are members (Mexico, Costa Rica, Colombia, Panama and France). According to CITES (Appendix II), globally there are 231 species of corals listed in threatened categories, and this is high relative to the number of listed reef invertebrates, fishes or macroalgae (Davidson 2006). As stated by the IUCN Red List, 32.8 % of coral species were upgraded to a higher risk extinction category and between 30 and 40 % of coral reef species within the ETP are threatened or near threatened (Carpenter et al. 2008).

Worldwide, there are currently 46 UNESCO marine World Heritage Sites (WHSs). Of these, 11 contain coral reefs, and six are located within the ETP (Costa Rica: Guanacaste Conservation Area and Isla del Coco National Park; Panama: Coiba National Park and its special zone of marine protection; Ecuador: Galápagos Islands; Colombia: Malpelo Fauna and Flora Sanctuary; and Mexico: Islands and Protected areas of the Gulf of California) (Abdulla et al. 2013). The latter four WHSs represent 1.7 % of the total area of the ETP (239,031 km^2) according to the biogeographic provinces of Spalding et al. (2007).

Even if the ETP coral reef region represents 'the minimum expression of coral reef development' (Cortés 1997),

it supports a unique flora and fauna that has persisted for thousands of years under marginal and stressful environmental conditions (Cortés 1997, 2003; see Chap. 7, Cortés et al.). The ETP is a unique biogeographic region—a natural laboratory—and can be used as a model to understand the fate of coral biotopes in a changing environment (Manzello 2010a, b). In addition, studies undertaken in the ETP region can provide clues for addressing the future conservation of coral reefs worldwide. At present, approximately 20 % of the region's coral reefs are included within some sort of conservation initiative (Mora et al. 2006), and 10 % of the coral species are under elevated risk of extinction according to IUCN criteria (Carpenter et al. 2008). This is driven by several factors, including the issue that many MPAs in the region allow extractive uses, and only a few are 'no-take' areas. The goal of this chapter is to review the coral reef conservation strategies in the ETP, with a focus on the implementation of MPAs and other legal instruments to protect coral reefs. In this sense, a chief objective is to assess if these tools are effective in the region, and whether there is a need to consider different types of conservation initiatives.

21.2 Country Initiatives

21.2.1 Mexico

Protected areas in Mexico are managed at different administrative levels, including federal, state or municipal entities. At present, only federally protected areas receive financial support. The National Commission for Protected Areas (Comisión Nacional de Áreas Naturales Protegidas-CONANP) is the main organization tasked with oversight, specifically by facilitating the protection of biodiversity and managing natural resources. CONANP coordinates with three other Mexican government agencies (Comisión Nacional de Acuacultura y Pesca-CONAPESCA, Procuraduría Federal de Protección al Ambiente-PROFEPA and Comisión Nacional para el Conocimiento y Uso de la Biodiversidad-CONABIO) to ensure that marine areas are appropriately managed for the benefit of both ecosystems and society.

Mexico's current administrative and organizational arrangement for managing protected areas has caused confusion and delays in effective implementation. The complexity of the governmental structure is compounded by Mexican law, which requires a four and a half year period between the declaration of an MPA and its implementation. In addition, only 68 % of Mexico's MPAs have some type of management plan, and some of these lack clarity on how different species would be protected. In addition, there are no clear strategies on how to manage potential conflicts between stakeholders (Rivera 2011). It is evident there is no appropriate design and planning of the Mexican MPAs; for example, important biological criteria have not been considered (López-Pérez and López-García 2008).

Limited financial support has hindered the goals of MPAs by curtailing the human resources needed to implement, update and improve management plans, and for carrying out monitoring and enforcement activities. For instance, CONAPESCA has fewer than ten staff members in the Gulf of California, an area with the highest number of MPAs in the Mexican Pacific, and of considerable global marine significance with three of the most profitable fisheries states in Mexico (Sonora, Sinaloa, and Baja California Sur). In a given year, there are nearly 18,000 artisanal boats (*pangas*) that work in the Gulf, totaling nearly 36,000 labor days for people involved in fisheries in this region.

The lack of enforcement within MPAs makes for a porous system: rule-breakers regularly engage in illegal fishing, with estimates of up to 50 % of total fishing activity being illegal or unreported, and pervasive fishing in no-take zones in the Upper Gulf of California and the Colorado River Delta. Furthermore, the current governance structure for MPAs has made enforcement almost impossible. This diminishes the ability of MPAs to be successful, and undermines confidence in the capacity of government institutions. Without better communication to distribute management resources among agencies, the ongoing establishment of MPAs by CONANP will continue to burden national agencies such as CONAPESCA and PROFEPA.

In recent years, several new MPAs have been established and conservation sites of significant priority have been identified for future expansion. However, without an assessment of MPA effectiveness, the value of such initiatives for ecosystem resilience or resource protection is debatable. The investments of governments in MPAs include significant human and economic resources for planning, but often do not include implementation and evaluation. Perhaps for such reasons, several scholars have described some MPAs as 'paper parks': administratively real, but practically useless (Rife et al. 2012).

Another issue is that most MPAs do not adequately include habitats within their territories to be effective buffers against overfishing and other anthropogenic stressors. The relatively limited coverage of marine ecosystems—especially deep-sea zones—within Mexico's MPAs suggests the need to incorporate pelagic and benthic environments in management plans to effectively conserve biodiversity. Also, for corals some of these areas do not represent the whole range of distribution for some species. For example, the Huatulco National Park includes approximately only 60 % of the species of corals in the State of Oaxaca (n = 17 species total), and excludes some populations that are important in maintaining regional connectivity (CONABIO et al. 2007). Other key stressors for MPAs in general include intensive trawl fishing and pollution from urban areas and

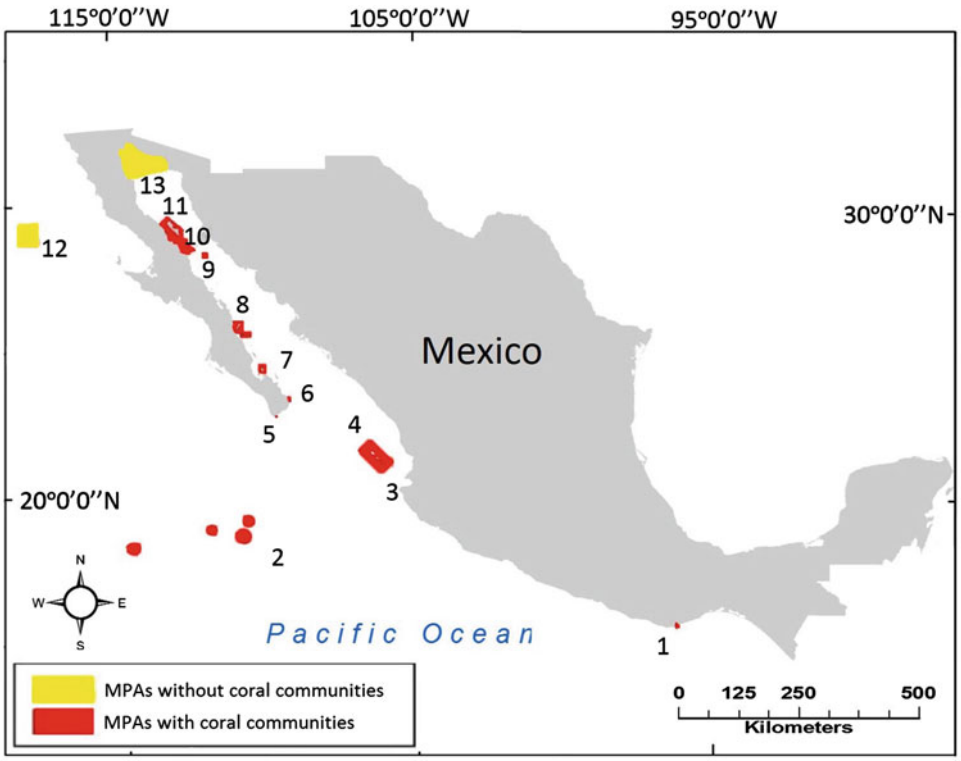

Fig. 21.1 Marine protected areas of western Mexico. *1* Huatulco National Park; *2* Revillagigedo Archipelago Biosphere Reserve; *3* Islas Marietas National Park; *4* Islas Marías Biosphere Reserve; *5* Cabo San Lucas Protected Area for Flora and Fauna; *6* Cabo Pulmo National Park; *7* Espíritu Santo Archipelago National Park; *8* Loreto Bay National Park; *9* Isla San Pedro Martir Biosphere Reserve; *10* San Lorenzo Archipiélago National Park; *11* Bahía de Los Ángeles Biosphere Reserve; *12* Isla Guadalupe Biosphere Reserve; *13* Upper Gulf and Colorado Delta Biosphere Reserve

agriculture. Yet, it will be important to balance the needs of industry and support for artisanal fishing with conservation goals. One approach would be to designate a specialized division for overseeing fishing activities inside MPAs. In the Gulf of California, there are eleven multi-purpose MPAs that are situated close to fishing grounds and human settlements (Fig. 21.1), with only a few currently designated as 'no take areas'. With the exception of Cabo Pulmo National Park, Mexico's MPAs have not met conservation or sustainability goals (Rife et al. 2012).

Cabo Pulmo National Park is often considered one of the most successful MPAs, not only in Mexico but worldwide, based on the species richness, diversity, resilience and productivity of its ecosystems (Calderón-Aguilera et al. 2007; Aburto-Oropeza et al. 2011; Rife et al. 2012; Reyes-Bonilla et al. 2014). The park is also considered a model for ecosystem-based management in rural settings, where people often rely on local natural resources for their basic livelihood. It is a place where boat captains, dive masters and local people come together to enforce the regulations of the park for both visitors and themselves. Additionally, the community participates in activities that include surveillance, fauna protection (e.g. sea turtle nesting sites), and beach programs. In 2009, a comparative study assessed changes in fish diversity and biomass at the park (between 1999 and 2009), relative to other MPAs and unprotected areas in the Gulf of California. This study concluded that Cabo Pulmo National Park has been an effective marine reserve with the recovery of reef fish biomass within its boundaries. Notably, the park exhibited the largest absolute recovery of biomass in a marine reserve (>460 %), and the most rapid relative increase in biomass of top predators, with a 30 % annual increase of this trophic category (Aburto-Oropeza et al. 2011).

The ecological reasons for such a large increase in fish biomass include several factors that can likely serve to protect other reefs within MPAs: (1) the reserve is large and thus can support permanent populations of large reef fishes with large home ranges; (2) the coral habitat is largely intact and healthy; (3) the reserve includes spawning areas for large predators; and (4) it is located in an area of upwelling and high productivity driven by the hydrodynamic forces generated by long basalt dykes, and its location in a transition zone near the entrance of the Gulf of California and the open waters of the Pacific Ocean.

The Cabo Pulmo MPA illustrates that recovery of a degraded fish community is possible when located in the right area and managed correctly, even to the level that is comparable to remote habitats that were never impacted by fishing and other local human activities. In recent years, ecotourism has become an important alternative livelihood for the residents of Cabo Pulmo (Aburto-Oropeza et al. 2011).

In 2008, a study was conducted to identify priority sites for the conservation of reef-building corals in Oaxaca State, Mexico (López-Pérez and López-García 2008). This study reported the presence of 17 species of reef-building corals across 28 sites. Because of their size and extent of development, the Oaxacan reefs are considered to be among the most important Mexican Pacific coral reefs. Additionally,

the study found that Huatulco National Park (located in Oaxaca) does not include all the coral reef species existing in Oaxaca and excludes key populations that are necessary to maintain connectivity among coral reef systems of Central America and Mexico. Identifying priority conservation sites and establishing a network of MPAs are crucial for the protection of Mexican coral reef ecosystems (López-Pérez and López-García 2008).

In Mexico, coral reefs have limited legal protection; ocean law and policy are fundamental to ocean conservation. The *General Law on Ecological Equilibrium and Environmental Protection* (LGEEPA) defines the establishment, administration and evaluation of Mexican MPAs. Threatened coral species that are listed under the Official Mexican Norm NOM-059-SEMARNAT-2010 have some degree of protection. Coral species are protected under the law NOM-022-SEMARNAT-2003, which specifies the preservation, conservation and restoration of coastal wetlands.

In order to protect Mexico biodiversity and foster compatible economic development interests in coastal areas, MPAs with no-take zones are needed, especially where Pacific reefs and mangroves are located, increasing the core zone of several existing MPAs. Proper enforcement of existing MPAs is also crucial (Ezequiel et al. 2011; Rife et al. 2013). Additionally, MPAs should involve local communities in management and decision-making processes alongside government authorities (Nava and Ramírez-Herrera 2011). Numerous studies advocate for a move from 'top-down' (state or agency control) to more 'bottom-up' (control by local communities) or locally-managed approaches for coastal protection and management, mainly in situations where little or no data are available (White et al. 1994, 2000; Johannes 1998a, b; Pomeroy and Rivera-Guieb 2006; Ramírez-Herrera et al. 2010).

21.2.2 El Salvador

In the early 1970s the government of El Salvador established an authority to manage natural resources, encompassing wildlife and forests on a national scale. Subsequently, the National Parliament declared some additional natural protected areas, including a mangrove ecosystem. After the Earth Summit in Rio de Janeiro (Brazil) in 1992, authorities created an institutional framework for environmental topics as well as wildlife legislation. It was not until 2005 that a new law allowed the Ministry of the Environment and Natural Resources to declare Natural Protected Areas (NPAs). In 2007–2008, environmental authorities, following a series of technical meetings with stakeholders, established the first NPA at Complejo Los Cóbanos (Fig. 21.2, site LC). The non-governmental organization (NGO) FUNDARRECIFE promoted scientific surveys, local environmental education and awareness, and was a critical partner in the implementation of Complejo Los Cóbanos.

Los Cóbanos NPA covers 20,600 ha, and includes oceanic, benthic (coral communities), mangrove ecosystems, and a tropical dry forest. Early studies at Los Cóbanos confirmed

Fig. 21.2 Marine protected areas on the Pacific coast of El Salvador. "Complejo Los Cóbanos" (LC). Estuarine Ramsar sites: "Complejo Bahía de Jiquilisco" (BJ), "Complejo Jaltepeque" (EJ). Western rocky shores, La Libertad department (LL); La Unión (LU), Gulf of Fonseca (GF). Scleractinian zooxanthellate coral communities (*filled circle*), other non-reef building cnidarian species (*filled triangles*)

the presence of large colonies of *Porites lobata* (>2 m diameter), a highly sought after conch (*Lobatus galeatus*), macroalgal cover, important fisheries species, and low pollutant levels (Barraza 2011). This is the only locality in El Salvador where reef-building coral species have been reported: *P. lobata*, *Psammocora obtusangula* and *Psammocora stellata* occur at shallow depths (0–2.5 m), covering at least 1.0 km^2 within the area. Surveys have demonstrated that *P. lobata* is the most abundant species. The recovery of dead pocilloporid fragments in the area suggests the presence of coral patches of at least four species of *Pocillopora* (Reyes-Bonilla and Barraza 2003). Other hard and soft corals occur in this NPA, as well as many coral-associated invertebrates and fishes. The NPA also provides an important foraging area for hawksbill turtles (*Eremochelys imbricata*), nesting grounds for other species of sea turtles, and more recently humpback whales have been sighted offshore during the dry season (November–March). Current research at Complejo Los Cóbanos includes biodiversity surveys of reef fishes (Barraza 2013) as well as coral health (unpub. data).

Local environmental consciousness has evolved within the community as well as nationally with the support of environmental NGOs. One effect has been to support the protection of Los Cóbanos, where authorities exercise national regulations to protect natural resources. A few of El Salvador's key legal instruments include:

- The Wildlife Conservation Law (from 1993), which requires authorization to collect or hunt protected species, determines species' conservation status and defines the penalties of law-breaking activities. All hard corals are protected by law, and cannot be killed or harmed, and their collection for scientific purposes requires authorization.
- The 1998 Environment Law declares mangroves and coral habitats as sensitive ecosystems, therefore human disturbances are not allowed. Also environmental permits for projects close to coral habitats are required. This has led to the improvement of the management of solid and liquid wastes as well as the mitigation of other impacts in the surrounding areas.
- The 2005 Natural Protected Areas Law has legalized human settlements within all NPAs, and prohibits new infrastructures. This law also requires permission for economic activities as well as hunting and collecting.

Currently, El Salvador's Ministry of the Environment is developing a management plan for Los Cóbanos. Implementing this plan will require approval and agreement with local communities, mainly fishers who harvest invertebrates and fishes. After the legal declaration of this NPA, some arrests occurred in a combined action between environmental representatives of the Ministry, NGOs, and police. The most important cases were related to the poaching of holothurians (sea cucumbers, currently threatened by extinction within national legislation), shipwrecks, and the collection of the intertidal mollusc *Chiton stokesi*. In all cases, offenders were jailed and released after judges reviewed their cases (within 72 h). These actions and local environmental awareness reduce the poaching of marine wildlife within NPAs.

Other threats that may affect Los Cóbanos are: the unplanned use of land for tourism, the use of illegal nets and other fishing devices, pollution from human settlements, inadequate agricultural practices, and increased sedimentation resulting from livestock activities. Some positive achievements after the declaration of this NPA are: increased environmental awareness, a decrease in illegal extractions, improved local coordination for the nesting and incubation of sea turtle eggs, and the assignment of permanent environmental wardens.

21.2.3 Nicaragua

Four MPAs have been established along the Pacific coast of Nicaragua: (1) Natural Reserve (NR) Estero Padre Ramos; (2) NR Juan Venado; (3) Wildlife Refuge (WR) Río Escalante-Chacocente; and (4) WR La Flor (http://www.marena.gob.ni/) (Fig. 21.3). None of these, however, is concerned with the protection of the recently identified coral biotopes in Nicaragua (Alvarado et al. 2010, 2011a; see Chap. 5, Glynn et al.). Their conservation objectives are directed towards sea turtle nesting sites. There is now an urgent need for the establishment of MPAs around the area of Punta Gigante (11°23′07.9″N; 86°02′12.4″W), where vibrant coral reef formations have been recently discovered (Alvarado et al. 2010, 2011a).

In conservation terms, the small number of MPAs on the Nicaraguan Pacific coast could compromise the latitudinal (north-south) dispersal and connectivity of ETP coral populations. This potential problem could be critically increased with the construction of the Nicaragua transoceanic canal (Fig. 21.3). Canal construction, which began in December 2014, will involve the excavation of hundreds of km of terrain from coast to coast. No environmental or economic feasibility studies have been revealed to the public. The probable canal route cuts through a coastal Caribbean natural reserve, traverses Lake Nicaragua, and is estimated to destroy around 400,000 ha of rainforest, wetlands, and marine ecosystems (Meyer and Huete-Pérez 2014). Multiple autonomous indigenous communities also are threatened. In terms of coral biotopes, canal construction will likely threaten the Caribbean reefs of Corn Island and Cayos Perlas, and poses a major threat to coral communities adjacent to the proposed Pacific terminus, especially in the vicinity of San Juan del Sur. These coral habitats are already exposed to stressful conditions during upwelling (December–April), and to sedimentation and salinity fluctuations in the wet season (June–

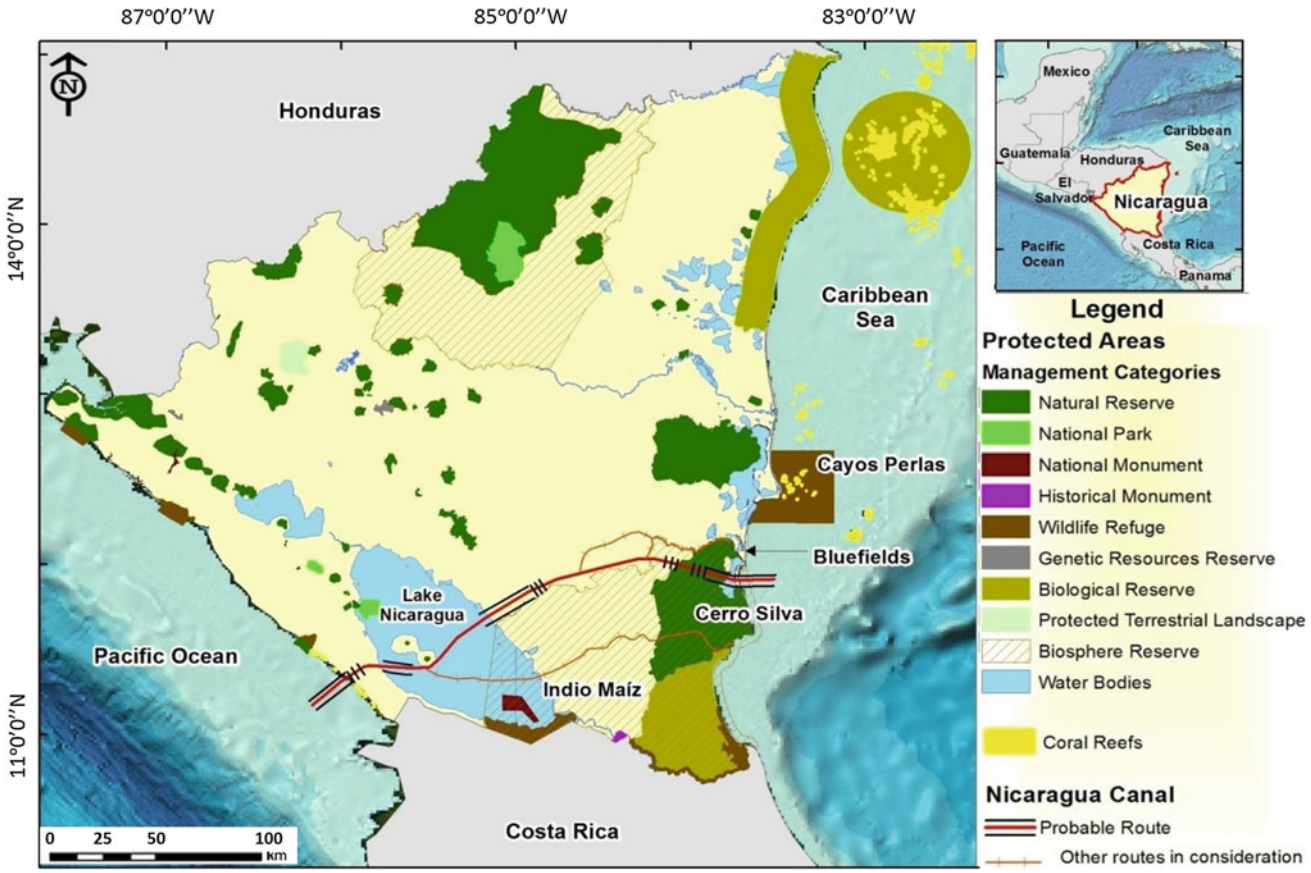

Fig. 21.3 Nicaragua's protected areas and probable route of interoceanic canal (modified from http://www.marena.gob.ni/, and Meyer and Huete-Pérez 2014)

November). The construction of the Nicaraguan canal could likely be a limiting factor for the continued existence of coral habitats on the Pacific coast of Nicaragua.

21.2.4 Costa Rica

Costa Rica has 167 protected areas (Environmental Ministry) and eight Responsible Fishing Areas (Fishery Authority) that together cover approximately 50 % of the Pacific and Caribbean coastlines. Twenty-six of these areas are MPAs classified as National Parks, National Wildlife Refuges, National Wetlands, Biological Reserves, Absolute Natural Reserves, Marine Management Areas, and Responsible Fishing Areas (RFA), which accord some level of protection for 16,048 km^2 of national waters (Alvarado et al. 2012; Salas et al. 2012; Fargier et al. 2014). Costa Rica possesses 970 km^2 of coral communities and coral reefs (0.3 % of the world's total coral reef area), and 80 % of coral habitats are located inside MPAs. It is estimated that 93 % of the coral areas are at risk (Spalding et al. 2001). On the Pacific coast, 11 MPAs contain coral reef habitats (Fig. 21.4; Table 21.1), covering an area of 4648 km^2. Ten of these are no-take MPAs, and one is a multi-purpose protected area (Golfo Dulce RFA). With the exception of the latter, the MPAs were created as extensions of their terrestrial counterparts with few studies on the merits of marine protection in their respective areas. Over time, however, studies have increased to describe and evaluate the areas in terms of supporting improved conservation management actions (Cortés et al. 2010). Nevertheless, some MPAs are considered to be 'paper parks' because control and surveillance actions are limited, mainly due to an insufficient number of park custodians. In some cases, park personnel lack the capacity to effectively manage MPAs, or their capacity to respond to threats is limited. Insufficient training and knowledge of the marine environment also affect performance and therefore protection.

The government of Costa Rica is a signatory of several international treaties (CITES, CBD, AGENDA 21, UNCLOS, RAMSAR, among others) and has several laws–such as its Wildlife Law, a Fisheries and Aquaculture Law, National Coastguard Creation Law and Environment Organic Law—for protecting and managing coral reef ecosystems. Despite this legal framework, Costa Rica does not currently have a specific legal instrument for the protection of coral reefs (AIDA 2012; Fonseca 2013). During the past ten years, however, a multidisciplinary group has

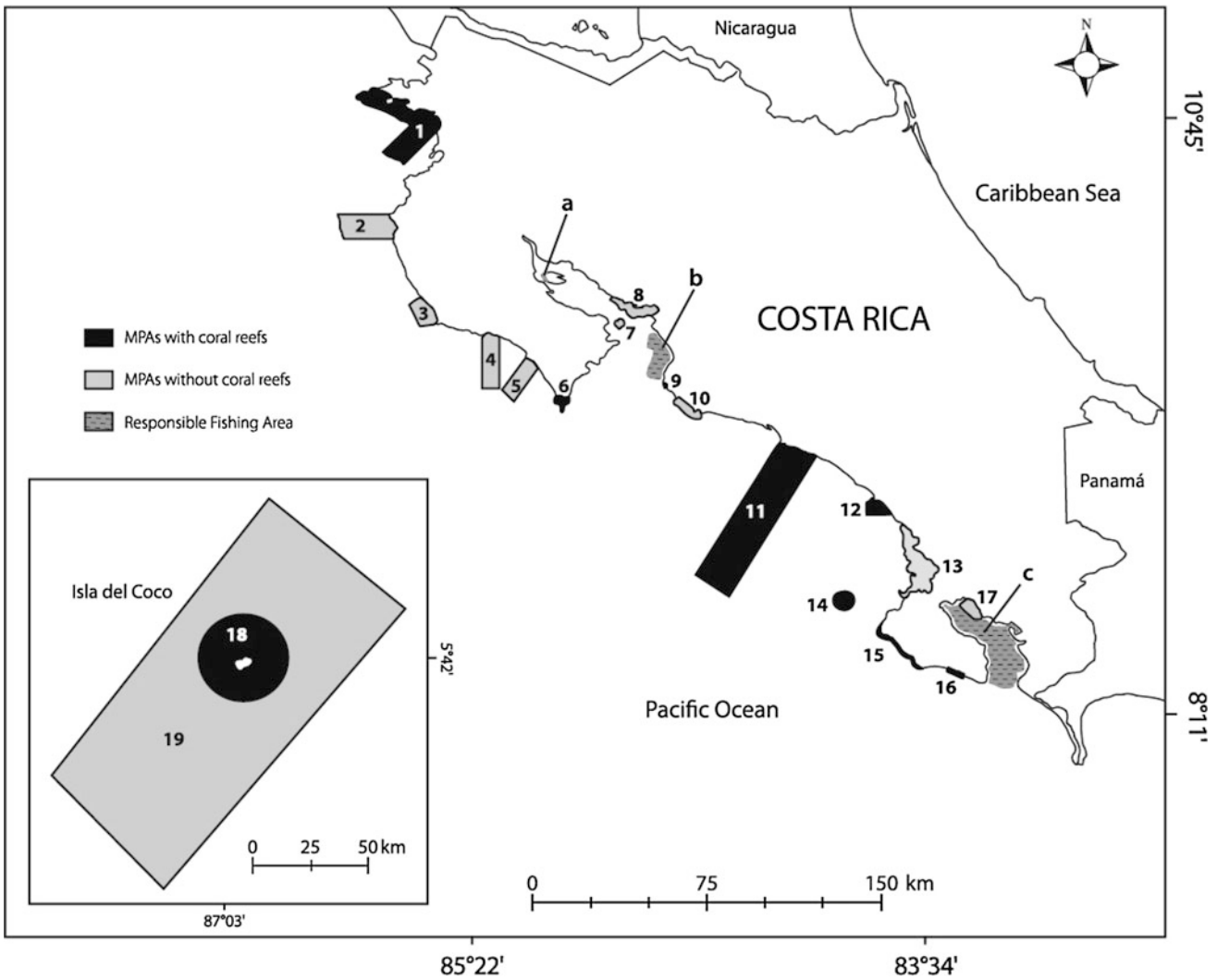

Fig. 21.4 Marine protected areas on the Pacific coast of Costa Rica. *1* Santa Rosa NP; *2* Marino Las Baulas NP; *3* Ostional NWR; *4* Caletas-Ario NWR; *5* Camaronal NWR; *6* Cabo Blanco ANR; *7* Isla San Lucas NWR; *8* Estero de Puntarenas NW; *9* Playa Blanca NW; *10* Playa Hermosa-Punta Mala NWR; *11* Manuel Antonio NP; *12* Marino Ballena NP; *13* Térraba-Sierpe NW; *14* Isla del Caño BR; *15* Corcovado NP; *16* Río Oro NWR; *17* Piedras Blancas NP; *18* Isla del Coco NP; *19* Montes Submarinos MMA; *a* Chira RFA; *b* Tarcoles RFA; *c* Golfo Dulce RFA. *NP* National Park; *NWR* National Wildlife Refuge; *BR* Biological Reserve; *ANR* Absolute Natural Reserve; *NW* National Wetland; *MMA* Marine Management Area; *RFA* Responsible Fishing Area

been working on the creation of an Executive Decree for the protection of coral reef environments (Fonseca 2013). Recent efforts supported by NGOs, such as Conservation International (CI)—Costa Rica, and AIDA, along with the University of Costa Rica (CIMAR), have initiated an evaluation of ecosystem services provided by coral reefs. This group also has leverage to improve a draft of the decree for approval by the Ministry of Environment. This decree will regulate activities that may affect the condition and development of coral reefs, such as sedimentation, extraction, anchor damage, coastline infrastructure development, and also the coordination of an improved mapping effort of the country's coral reefs, and the establishment of an ecological and health monitoring program.

Although there is great awareness in Costa Rica of the importance of coral reefs, there is still much to protect. In years past, conservation deficiencies were identified in terrestrial, freshwater and marine ecosystems. Coral reef ecosystems have become a key focus for marine conservation in recent years (Alvarado et al. 2011b). While the latest conservation gap analysis demonstrated improvements in protecting coral reefs, it also indicated that in many areas there is a lag in updating their health status, and not all regions have adequate baseline information or continuous monitoring programs. In turn, it was found that there are still many coral habitats in need of protection. To remedy this deficiency, new strategies will be required to avoid social conflicts with the presence of MPAs and also to avoid the

Table 21.1 Marine protected areas of the ETP with coral habitats and/or coral reefs

Country and sites	MPA category	IUCN category[a]	Marine area (km^2)	Year established	Other category	Take–no take	Source
Mexico							
Bahía de Los Ángeles, Canal de Ballenas y Salsipuedes	Biosphere Reserve	VI	3879.57	2007		No take 0.05 %	CONABIO et al. (2007); http://www.protectedplanet.net/
Loreto	National Park	II	2065.81	1996	Ramsar site, world heritage site	No take 0.07 %	CONABIO et al. (2007); http://www.protectedplanet.net/
Isla Espíritu Santo	National Park	II	486.55	2007		No take 1.4 %	CONABIO et al. (2007); http://www.protectedplanet.net/
Cabo Pulmo	National Park	II	71.11	2000	Ramsar site, world heritage site	No take 35.1 %	CONABIO et al. (2007); http://www.protectedplanet.net/
Islas Marietas	National Park	II	13.83	2005	Ramsar site, world heritage site, man and biosphere	No take 0.8 %	CONABIO et al. (2007); http://www.protectedplanet.net/
Islas Marías	Biosphere Reserve	VI	3172.57	2000	World heritage site	No take 2.4 %	CONABIO et al. (2007); http://www.protectedplanet.net/
Archipiélago de San Lorenzo	National Park	II	584.43	2005	World heritage site	No take 15.1 %	CONABIO et al. (2007); http://www.protectedplanet.net/
Cabo San Lucas	Fauna and Flora Protection Area	VI	39.96	1973	World heritage site	Take 100 %	CONABIO et al. (2007); http://www.protectedplanet.net/
San Pedro Martir	Biosphere Reserve	VI	298.76	2002	Ramsar site, world heritage site, man and biosphere	No take 3.7 %	CONABIO et al. (2007); http://www.protectedplanet.net/
Huatulco	National Park	II	46.77	1998	Ramsar site		CONABIO et al. (2007); http://www.protectedplanet.net/
Revillagigedo	Biosphere Reserve	I	6231.26	1994	Ramsar site, world heritage site	No take 0.07 %	CONABIO et al. (2007); http://www.protectedplanet.net/
El Salvador							
Los Cóbanos	Not defined yet	Not yet defined	206.8	2008		100 % take until management plan is approved	Diario Official, 12 February 2008, Volume 378, number 29
Costa Rica							
Santa Rosa	National Park	II	461.2	1971	UNESCO World Heritage site	No-take (100 %)	Alvarado et al. (2012), Salas et al. (2012)
Cabo Blanco	Absolute Natural Reserve	I	16.7	1963		No-take (100 %)	Alvarado et al. (2012), Salas et al. (2012)
Playa Blanca	National Wetland	IV	0.05	1994		No-take (100 %)	Alvarado et al. (2012), Salas et al. (2012)
Manuel Antonio	National Park	II	1243.7	1972		No-take (100 %)	Alvarado et al. (2012), Salas et al. (2012)
Marino Ballena	National Park	II	52.2	1992		No-take (100 %)	Alvarado et al. (2012), Salas et al. (2012)

(continued)

Table 21.1 (continued)

Country and sites	MPA category	IUCN category[a]	Marine area (km^2)	Year established	Other category	Take–no take	Source
Isla del Caño	Biological Reserve	I	55.3	1978		No-take (100 %)	Alvarado et al. (2012), Salas et al. (2012)
Corcovado	National Park	II	19.8	1975		No-take (100 %)	Alvarado et al. (2012), Salas et al. (2012)
Río Oro	Wildlife Refuge	II	16.9	1999		No-take (100 %)	Alvarado et al. (2012), Salas et al. (2012)
Piedras Blancas	National Park	II	13.2	1991		No-take (100 %)	Alvarado et al. (2012), Salas et al. (2012)
Golfo Dulce	Responsible Fishing Area	V	773.97	2010		Take (100 %)	Salas et al. (2012)
Isla del Coco	National Park	II	1994.7	1978	Ramsar site, UNESCO World Heritage site	No-take (100 %)	Alvarado et al. (2012), Salas et al. (2012)
Panama							
Golfo de Chiriquí	National Park	II	194.93	1994		No-take and take	ANAM–PMDSCH (2010)
Isla Montuosa y Banco Haníbal	Special Zone of Marine Protection	Not yet matched with IUCN	1782.33	2004[b]	UNESCO World Heritage site	Take	ANAM (2009), Cunningham et al. (2013)
Coiba	National Park	II	2,024.63	1991	UNESCO World Heritage site	No-take	Glynn and Maté (1997), Maté (2003), Guzmán et al. (2004), ANAM (2009)
Sur de Veraguas	Special Management Zone	Not yet matched with IUCN	1791.35	2008		Take	Maté (unpublished)
Cerro Hoya	National Park	II	36.33	1984		Take	Maté (2003)
Isla Iguana	Wildlife Refuge	IV	0.94	1981		No-take	Guzmán et al. (1991), Maté (2003)
Taboga	Wildlife Refuge	IV	0.45	1984		Take	Maté (2003)
Archipiélago de Las Perlas	Special Management Zone	Not yet matched with IUCN	1356.18	1984		Take	Maté (2003), Guzmán et al. (2008)
Colombia							
Gorgona	Natural National Park	II	616.87	1984			Muñoz and Zapata (2012); http://www.protectedplanet.net/
Malpelo	Flora and Fauna Sanctuary	IV	8571.5	1995	UNESCO world heritage site		http://www.protectedplanet.net/
Ensenada de Utría	Natural National Park	II	543	1986			http://www.protectedplanet.net/
Bahía Málaga	Natural National Park	II	470.94	2010			http://www.protectedplanet.net/
Ecuador							
Galápagos	Marine Reserve	VI	138,000	1998	UNESCO world heritage site	Multiple-purpose	Danulat and Edgar (2002)

(continued)

Table 21.1 (continued)

Country and sites	MPA category	IUCN category[a]	Marine area (km^2)	Year established	Other category	Take–no take	Source
Galera-San Francisco	Marine Reserve	VI	546	2008		Multiple-purpose	NAZCA (2013)
Machalilla	National Park	II	144.3	1979	Ramsar site	Multiple-purpose	MAE (2007a, b); http://www.protectedplanet.net/
El Pelado	Marine Reserve	VI	130	2012		Multiple-purpose	http://www.protectedplanet.net/
Puntilla Santa Elena	Coastal-Marine Faunal Production Reserve	VI	472.74	2008		Unknown, probably multiple-purpose	Samaniego (2010)
Isla Santa Clara	Wildlife Refuge	IV	73.43	1999	Ramsar site	Multiple-use	Hurtado et al. (2010)
Chile							
Motu Motiro Hiva Marine Park (Salas y Gómez Island)	Marine Park	I	150,000	2010		No-take (74 %)	Friedlander et al. (2013); http://www.protectedplanet.net/ http://www.mpatlas.org/region/nation/CHL/
Coral Nui Nui	Marine and Coastal Protected Area	Not yet matched with IUCN	0.0855	1999		Multiple-use	Sierralta et al. (2011); http://www.mpatlas.org/region/nation/CHL/
Motu Taura	Marine and Coastal Protected Area	Not yet matched with IUCN	0.09	1999		No-take (100 %)	Sierralta et al. (2011); http://www.mpatlas.org/region/nation/CHL/
Hanga Oteo	Marine and Coastal Protected Area	Not yet matched with IUCN	1.65	1999		Multiple-use	Sierralta et al. (2011); www.mpatlas.org/region/nation/CHL/

[a]Primary management objectives (after Marine Protected Areas 2001)
I Strict Nature Reserve-Wilderness Area: protected area managed mainly for science or wilderness protection
II National Park: managed mainly for ecosystem protection and recreation
III Natural Monument: managed mainly for conservation of specific natural features
IV Habitat/Species Management Area: managed mainly for conservation through management intervention
V Protected Landscape/Seascape: managed mainly for landscape/seascape conservation and recreation
VI Managed Resource Protected Area: managed mainly for the sustainable use of natural ecosystems
[b] Year established by government of Panama (2004), by UNESCO World Heritage Site (2005)

creation of 'paper parks' that lack effective management. Several NGOs, including CI, Costa Rica Para Siempre, Keto, MarViva, and the German Society for International Cooperation, and the United Nations Development Program (UNDP), in cooperation with national universities, have been working in coordination with the government of Costa Rica to address these conservation deficiencies.

21.2.5 Panama

Coral reefs and coral communities on the Pacific coast of Panama are well represented within the regulatory scheme of MPAs. Eight marine areas provide protection to the largest and most important coral habitats in the Gulf of Chiriquí, a non-upwelling area in western Panama with seasonal shoaling of the thermocline, and the Gulf of Panama, a seasonal upwelling environment in the eastern half of Panama. These areas include three National Parks (Marino Golfo de Chiriquí, Cerro Hoya, and Coiba), two Wildlife Refuges (Isla Iguana, and Isla Taboga), one Special Zone of Marine Protection (Isla Montuosa and Banco Haníbal), and two Special Management Zones (Sur de Veraguas, and Archipiélago de Las Perlas) (Table 21.1, Fig. 21.5). Maté (2003) provided an overview of five of these coral reef ecosystems that include the national parks and the wildlife refuges, as they were the only ones established at that time (between 1984 and 1991). New coral habitats were not included in the protection

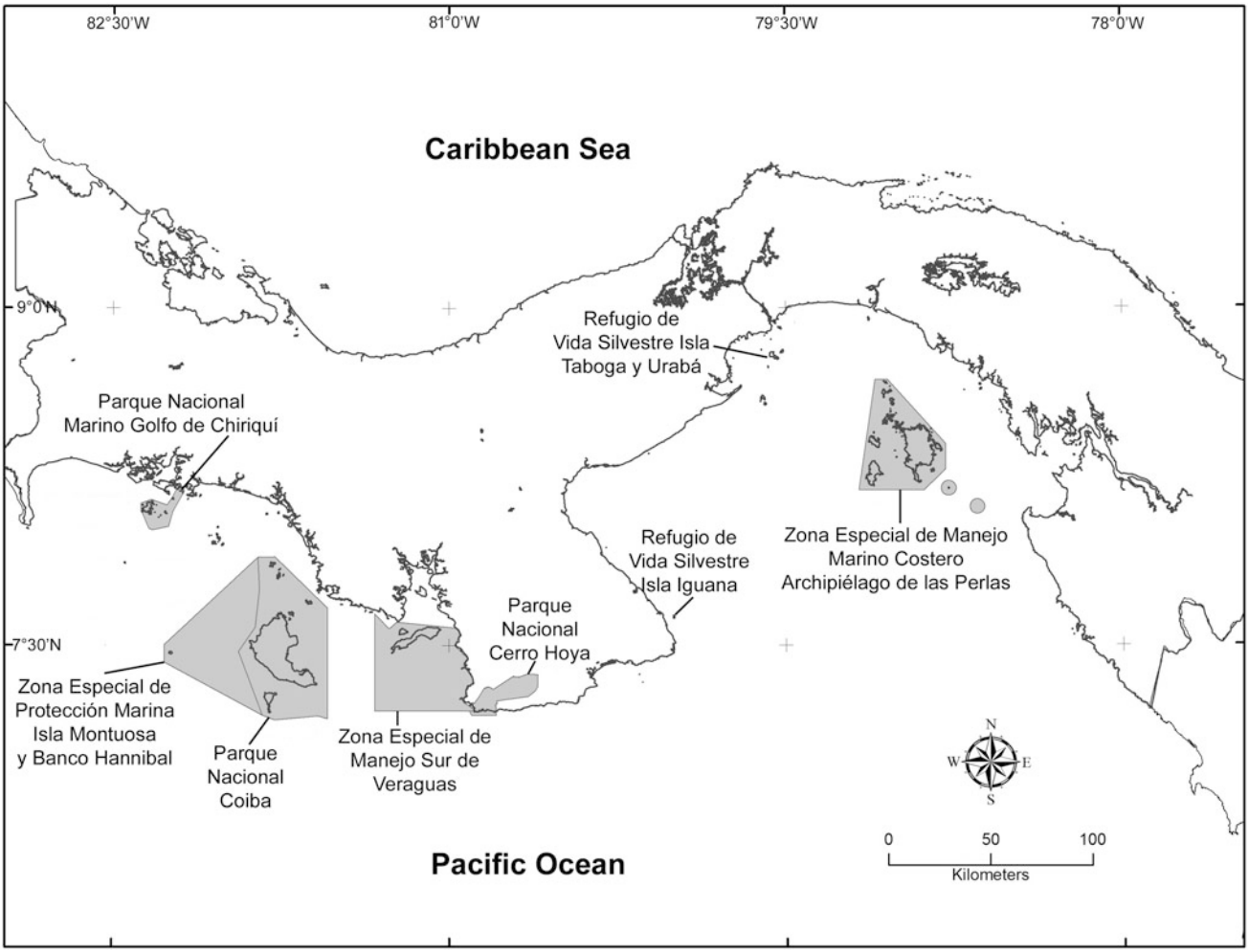

Fig. 21.5 Marine protected areas along the Pacific coast of Panama

scheme until 2004, under two new categories directed towards fisheries management, namely the Special Zone of Marine Protection, and the Special Management Zones, the latter first appearing in 2008 (Table 21.1).

The two largest MPAs in Panama with coral reef ecosystems are the Coiba National Park and the Special Zone of Marine Protection, the Archipiélago de Las Perlas. In 2004, the legal status of Coiba was upgraded to national law. In addition, a new area was established to the west of Coiba Island, and designated as the Special Zone of Marine Protection of Montuosa Island and Hannibal Bank (Zona Especial de Protección Marina Isla Montuosa y Banco Haníbal). This special zone is considered as a 'buffer zone' for the Coiba National Park. Both areas were inscribed together in 2004 in the UNESCO World Heritage List of Natural Sites as Coiba National Park and its Special Zone of Marine Protection under current criteria (ix) and (x). Coiba and its Special Zone encompass 3807 km^2 of marine area with approximately 40.5 km^2 of coral habitat (Table 21.1). Las Perlas MPA covers 1356 km^2 of area with approximately 3.1 km^2 of coral habitat.

While national parks and wildlife refuges have equivalents in the IUCN Protected Areas Categories System as National Park, and Habitat/Species Management Areas respectively, the Special Management Zones and the Special Zone of Marine Protection do not have equivalent classifications. The first three types of management areas under Panamanian regulations fall within the competency of the Ministry of Environment of Panama (MiAmbiente) and the latter under Panama's Aquatic Resources Authority (ARAP). Until March (2015), when MiAmbiente was created to replace the Panamanian National Authority for the Environment (ANAM), the Special Management Zones were under the jurisdiction of ARAP (see Maté 2003). MiAmbiente is now charged to reclassify this category to an equivalent in the IUCN Protected Areas Categories System.

Only the three national Parks (Cerro Hoya, Coiba, and Marino Golfo de Chiriquí) already have approved

management plans. Yet their implementation has been relatively poor due to insufficiently-trained staff, inadequate budgets, and a lack of necessary equipment. The Special Management Zone of the Archipiélago de Las Perlas has had a management plan since 2011, which was developed through a participatory process, but authorities have been unwilling to approve it due to competing political and economic interests. MiAMBIENTE acquired jurisdiction over this area in 2015 and at the beginning of 2016 began a process to revise and validate the management plan for approval.

Nevertheless, Coiba and its Special Zone as well as Las Perlas have a relatively strong legal framework provided by national laws. These protected zones will be the main areas covered in this section. Both areas are archipelagos but only Las Perlas includes human settlements. Since information on Coiba and Las Perlas reef-building coral cover and condition is presented in Chap. 5 (Glynn et al.), we here note only some brief complementary remarks. The Coiba MPA consists of 39 main islands with no resident communities except for a small contingent of park rangers and law enforcement officers. The coral communities and reefs are considered among the most extensive in the eastern Pacific, comprising more than 17 km^2 of high biological diversity and endemism (Guzmán et al. 2004). For example, 30 species of octocorals, 20 scleractinian corals, and four hydrocorals have been reported from Coiba (Glynn and de Weerdt 1991; Glynn and Maté 1997; Glynn and Ault 2000; Breedy and Guzmán 2003, 2004, 2005; Maté 2003; Guzmán et al. 2004; Lindner et al. 2004). Two octocorals, *Pacifigorgia catedralensis* and *Leptogorgia christiae,* are endemic to the park and have been found only at a single location there (Breedy and Guzmán 2004, 2008; Guzmán and Breedy 2008). The octocorals *Pacifigorgia rubinoffi*, *Pacifigorgia smithsoniana*, and the stylasterid lace coral *Distichopora robusta* are mainly concentrated around Coiba, even though they also occur at a few other localities in the Gulf of Chiriquí (Breedy and Guzmán 2003; Lindner et al. 2004). *Pacifigorgia smithsoniana* is also found in the Special Management Zone of the Archipiélago de Las Perlas, Gulf of Panama.

The Special Zone of Marine Protection includes Hannibal Bank, an elongated, triangular guyot (Cunningham et al. 2013), which is considered one of the most important fishery areas in Panama for both commercial (snappers, groupers, and dolphin fish), and sport fishing (billfish and tuna) species (ANAM 2009; Vega et al. 2011). Approximately 40.5 km^2 of the Bank is firm substrata between 54 and 416 m in depth. The relatively shallow rugose areas probably contain corals that support a high faunal diversity (Cunningham et al. 2013).

In terms of resources and activities carried out in the park, the Coiba zoning plan for the marine environment consists of two types of marine areas: a Marine Reserve Zone (equivalent to a 'no-take zone') and a Resource Management Zone. The Marine Reserve Zone covers 23.5 % of the park, and includes most of the shallower substrates where corals are located. It is in this area, which includes the shorelines of the islands to a distance of 1.8 km offshore, where most of the directed recreation and ecotourism occur (snorkeling, diving, and beach activities). The Resource Management Zone includes the deeper areas of the park, which support marine fishery resources that can be harvested by artisanal and sport fishing. Numerous rock pinnacles with diverse coral communities are also present in the area, and are frequented for scuba diving and research. The Resource Management Zone also supports whale watching activities. A new fisheries plan has established regulations for fishing gear, catch limits, fishing effort, and the size of species that can be harvested.

Coral habitats with reefs and coral communities on rocky outcrops are of high interest for sport diving, and are frequented regularly by visitors, particularly those sites located in the northeastern area of the park. The Coiba Management Plan identifies 31 sites where these activities take place, and sets limits on the number of boats and divers allowed access at any given time. In addition, 40 mooring buoys have been installed at these sites to reduce the impact of anchor damage while also providing diving safety lines.

The management plan for the Special Zone of Marine Protection of Montuosa Island and Hannibal Bank has not yet been prepared although the World Heritage Committee (WHC) has long requested one. To wit: the World Heritage Committee Decision 37 COM 7B.31 of 2013, 'Request the State Party to urgently finalize a draft Management Plan for the Special Zone of Marine Protection, to adopt and initiate its implementation, and to start with the independent Management Effectiveness Evaluation in order to inform the effective management for both Coiba National Park and its Special Zone of Marine Protection'.

A UNESCO-IUCN monitoring mission conducted at Coiba Island in January 2014 (see Douvere and Herrera 2014) identified several issues that are negatively affecting the long-term conservation and effective management of the area. These threats reflect problems facing additional MPAs in Panama, including the Pearl Islands Archipelago, which is described in more detail below. The main threats identified by the mission include: (a) The small number of adequately trained staff, which results in a lack of effective management and enforcement; (b) A risk that fisheries, in particular illegal sport and commercial fisheries, poses a threat to the health of the Outstanding Universal Value (OUV) of the MPA. Sport fisheries is of particular concern as it seems to increase rapidly, targeting zones of spawning/nursing and where rare coral/high endemism occurs; (c) A lack of reliable information on the scope of resource extraction; (d) An increase in tourism, if not well managed, will pose a threat to the long-term conservation of the property's OUV; and (e) Coastal development within the boundaries of the MPA is inconsistent with the property's OUV and should be

relocated/restricted to areas outside the park's boundaries. As a result, WHC Decision 38 COM 7B.84 of 2014, 'Expresses its concern about the negative impact of fisheries, and in particular illegal and sport fisheries, on the OUV of the property, and urges the State Party to complete and implement the management plan for the Special Zone of Marine Protection (SZMP) as a matter of priority, which should include clear regulations related to fisheries management, i.e. no-take zones and seasonal closures of critical areas, such as Hannibal Bank, Montuosa Island'.

Coiba was for many years a penal colony until its closure in 2004. Livestock maintained at the prison became feral, and is one of the primary threats to the newly established park. The livestock (cattle) have caused the deterioration of large areas of top soil, producing loose sediments that have washed onto nearby coral reefs at Playa Blanca, the largest coral reef complex in the park. Recent efforts have been made to begin removing the island's remaining livestock. The UNESCO-IUCN monitoring reactive mission has acknowledged this effort, with the caveat '…considers important that the World Heritage Committee assesses closely its implementation in view of having all livestock removed from the property by end of 2014, as suggested by the State Party'.

The second area to be considered is the Special Management Zone of the Archipiélago de Las Perlas (Table 21.1, Fig. 21.5), which contains the largest aggregation of coral reefs in the seasonal upwelling Gulf of Panama (Glynn and Maté 1997). This Management Zone also includes two satellite areas to the southeast, namely Galera Island and Bajo Trollope. There are 250 rock islands and islets in the management zone with 39 octocoral and 19 known scleractinian species (Glynn and Maté 1997; Maté 2003; Guzmán et al. 2008). Areas with the highest coral cover are located both to the north (Contadora and Saboga Islands) and south (Pedro González, San Pedro, and San Telmo Islands). In contrast to Coiba Island, with no permanent residents, there are long-established communities on some of the larger islands, both in the northern and southern parts of the archipelago. However, most of the islands are uninhabited (Guzmán et al. 2008).

In contrast to Coiba, which was designated a national park to protect biodiversity and promote conservation, the Las Perlas MPA was created to implement an integrated coastal management approach focused on fisheries, tourism, and long-term landscape conservation (Guzmán et al. 2008). Important strategies being implemented to control local sedimentation include the protection of the main watersheds in the Del Rey Hydrological Reserve, and the creation of the San Jose Natural Private Reserve (Guzmán et al. 2008).

In addition to the traditionally recognized anthropogenic stressors, recent government authorization for the private prospecting of archeological artifacts in the waters of the archipelago has introduced new challenges near coral habitats. Large blowers with air supplied from nearby ships are being used to remove (blow-off) sediments to expose artifacts. Local communities are pressuring authorities to ban such operations near coral areas.

Even though the management plan for Las Perlas has not yet been adopted, 20 mooring buoys have been installed in areas identified in the proposed plan to reduce the impact of anchor damage to highly valued benthic ecosystems. The buoys were intended for the recreational and commercial boats supporting scuba and surface divers. However, improper use of the buoys by large ships is causing significant damage to the buoys as well as to surrounding benthic communities. Other activities to support the proposed management plan could include the incorporation of high diversity and high coral cover areas into no-take zones, which would contribute significantly to conservation efforts (Guzmán et al. 2008). A Conservation and Monitoring Unit was active at Las Perlas a few years ago, but has recently been terminated.

With the exception of published information on some of the other five marine areas with some level of protection (Guzmán et al. 1991; Glynn and Maté 1997; Maté 2003; Díaz 2005), there is little new information relating to management practices or strategies being prepared for implementation. Threats and local strategies that may be implemented at some of these sites do not differ significantly from those previously noted for the Coiba and Las Perlas MPAs.

21.2.6 Colombia

The Colombian Pacific coastline is about 1300 km in length, covers an area of approximately 367,823 km^2, and contains a population of around 1,370,000 inhabitants ($\sim$4 ind km^{-2}) (Romero 2009). There is little socio-economic development in the area, with only two coastal cities with large populations, namely Buenaventura and Tumaco (Fig. 21.6). This area, known as the Chocó, is characterized by geological variability, moderate atmospheric temperatures, high rainfall and relative humidity, and high terrestrial biodiversity (Díaz and Gast 2009).

Coral habitats comprise 14.4 km^2 of area, of which 3 % are oceanic and 97 % continental. Most of the Colombian Pacific coral areas are managed for conservation (Fig. 21.6). In fact, the only unprotected coral areas occur in the northern Chocó at Punta Piñas (Gulf of Cupica), La Tebada and Cabo Marzo (Fig. 21.6, see also Chap. 5, Figs. 5.18, 5.19). The major marine protected areas with coral habitats (structural reefs or otherwise) are located at Gorgona Island Natural National Park (NNP), the Malpelo Island Flora and Fauna Sanctuary (FFS), and Ensenada Utría NNP. At the Uramba Bahía Málaga NNP, isolated coral colonies have been found on a rocky reef at the entrance to the bay (Escobar and Neira 1992). Another NNP on the Colombian Pacific coast,

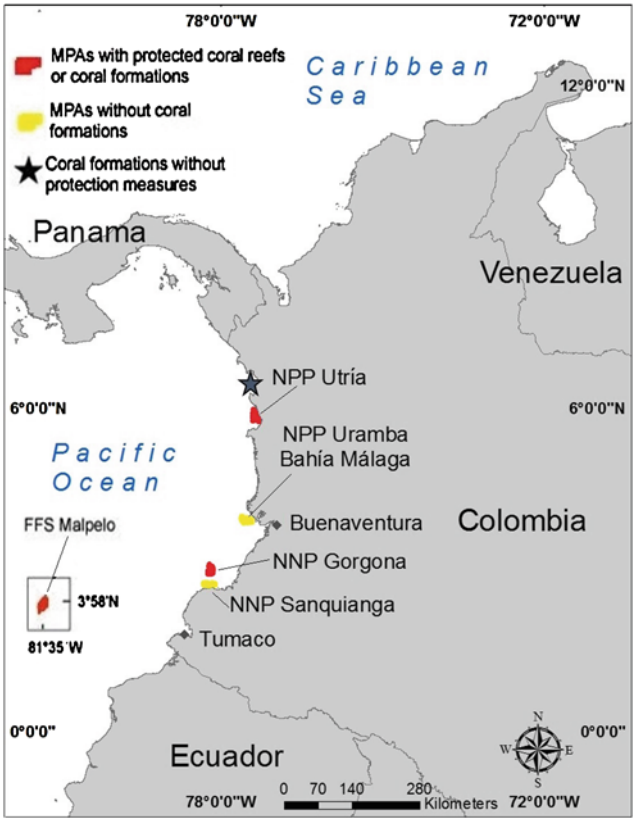

Fig. 21.6 Marine protected areas and other sites with and without coral habitats on the Pacific coast of Colombia

Sanquianga Park with 800 km^2 of protected mangroves and estuaries, is devoid of corals. All of these MPAs are under the jurisdiction of the Special Administrative Unit of the Natural National Parks System of the Ministry of Environment and Sustainable Development (MADS). Despite the level of protection from anthropogenic disturbances, all of these areas are subject to natural disturbances, such as freshwater runoff, sedimentation, and sporadic ENSO activity.

The Gorgona NNP is located in the southwestern sector of the Colombian Pacific. It is 616.8 km^2 in area, of which 14.8 km^2 (2.4 %) is land, including Gorgona Island, Gorgonilla Islet and rocky promontories (El Viudo and El Horno). Gorgona Island is 9.3 km long by 2.6 km wide, and is 35 km west of Punta Reyes on the mainland. Gorgona Island served as a high security prison for 25 years (1959–1984).

The Gorgona Park was established by executive resolution 141 in July 1984. New boundaries were established by resolution 1265 in October 1995. This declaration prohibits all activities other than conservation, research, education, recreation, and cultural studies. Restoration of the natural environment since the closure of the prison, and enforcement of protective park measures, is also permitted. It therefore meets IUCN Management Category II (National Park), which mandates ecosystem protection and recreation (Table 21.1). To date, three management plans have been developed for the park. In the first (2004–2010), coral reefs were established as the most significant NNP conservation target (UAESPNN 2004, 2005), and were prioritized for research, monitoring and conservation practices. A second plan (2007–2011) was adopted by resolution 053 in January 2007. Presently, a third management plan (2012–2017) focuses on increasing the level of basic knowledge of coral reefs, strengthening monitoring, and developing more robust outreach activities (Muñoz and Zapata 2012). To accomplish these goals, the proposed research guidelines include measures to expand knowledge and information on biodiversity, exploration of poorly known areas, species' biology, oceanographic conditions, ecological processes, natural and anthropogenic perturbations as well as monitoring the health state of coral reefs.

The Malpelo Island MPA consists of a group of islands and islets in the Colombian Pacific, 506 km west of Buenaventura. The principal island is 2.9 km long by 1.3 km wide with a maximum height of nearly 380 m above sea level. The main island is surrounded by 11 islets, four in the north (Los Tres Mosqueteros and D'Artagnan), two on the east side of the island (Vagamares and La Torta), and five at the island's south end (Los Tres Reyes, La Gringa and Escuba) (see Fig. 5.20, Chap. 5).

The island's marine life is diverse and vibrant, and is located within an International Conservation Hotspot. In 1995, by Resolution 1292, Malpelo Island was designated a Flora and Fauna Sanctuary. In 1996, the marine area was extended by Resolution 1423 to six nautical miles from the shoreline. In 2002, Resolution 0761 re-defined the marine boundaries. In 2003, the International Maritime Organization declared the Sanctuary a Particularly Sensitive Sea Area (PSSA), and in 2005 Resolution 1589 extended the park's boundaries from 654.5 to 8575 km^2. In July of 2006, the island was declared a World Natural Heritage Site by UNESCO under Natural Criteria VII and X. The IUCN Management Category is IV, i.e. a Habitat-Species Management Area. At present, the island is managed by a Special Administrative Unit of the Natural National Parks System, and is a key component of the National Fisheries Management Plan for Colombia's Pacific Region. The Park Unit and the Malpelo Foundation of Colombia protect the island. Since 2005 UNESCO, together with Conservation International, designated much of the equatorial eastern Pacific a Marine Biological Corridor of Conservational and Sustainable Development. This extensive network of MPAs includes coastal and oceanic islands between Costa Rica, Panama, Colombia and Ecuador, connecting the main coral habitats of the region (e.g., Cocos, Coiba, Malpelo, Gorgona, and the Galápagos Islands). The extended, protected area around Malpelo was declared a no-take zone.

Despite its designation as a marine sanctuary, some threats, such as illegal artisanal and industrial fishing, persist within and around Malpelo's marine protected zone. Hand,

seine and long-line fishing (with 1500–5000 hooks per line) contribute to overfishing of commercial species, especially sharks. Tourism, however, is carefully controlled and the concessions operating at Malpelo are mandated to undertake infrastructure maintenance and training of staff to effectively manage resources. El Niño disturbances have possibly affected Malpelo's coral habitats less than those at Gorgona Island, although the effects of the 1982–83 El Niño disturbance at Malpelo were not reported (Vargas-Ángel et al. 2001). Although there are recent documented records of *Acanthaster planci* on Malpelo Island (Narváez and Zapata 2010), sea star outbreak events are unknown.

Located on the north coast of the Colombian Pacific, the Utría NNP is part of the Chocó Biogeographic Province. It is considered to be of high conservation priority due to its biological diversity and species endemism. This MPA encompasses an elongate embayment 543 km^2 in area, and includes three villages: El Valle, Bahía Solano and Nuquí. The bay lies astride a geological fault, the Utría Fault. The coral reefs in the Utría NNP are unique in the Colombian Pacific because of their close association with extensive mangrove forests. The Utría NNP contains a 0.33 km^2 (33 ha) estuarine-mangrove ecosystem with at least five species of mangroves, which is fundamentally critical for the reproduction, protection, and development of a large number of marine species of both ecological and commercial value. In recent years, heavy exploitation has threatened some fish species in the MPA due to overfishing, the presence of semi-industrial fishing vessels, and the use of inappropriate fishing gear.

Utría National Park was created in the Department of Chocó according to Agreement 052 in 1986, and approved by Executive Resolution No. 090 in 1987. The original 543 km^2 area was expanded to include an additional 220 km^2 of protected forest. This MPA is characterized by high rainfall and species rich terrestrial and marine ecosystems. Most of the area is covered by a tropical rainforest with a high degree of endemism, and steep terrain with soils subject to erosive processes.

The objectives of the Utría NNP are stated in the mission purpose of the National Parks Unit, namely 'Ensuring the in situ conservation of biophysical and cultural diversity present in representative ecosystems of the country'. In addition, the conservation values are of strategic importance to the country's biodiversity and to local Emberá (native American) communities sharing the territory, and to ensure a sufficient supply of ecosystem services for sustainable human development that promotes conservation of culturally significant natural habitat.

Utría NNP is located in an area with limited human intervention, which in general terms creates good connectivity among the park's various landscape units. The park's primary goal is the conservation of representative ecosystems of the region. A second goal is the conservation of migratory species of high national and international ecological value, and a third goal is the conservation of environmental goods and services important to human populations that have settled within the park's boundaries. Finally, the fourth goal is the preservation of the cultural values of the indigenous Emberá nation.

The main threats currently facing the Utría MPA are: (1) Over-exploitation by an increasing fishing effort, and the impact of artisanal fishers using illegal fishing gear and ignoring catch size limits; (2) Logging in surrounding areas leading to the depletion of species of high commercial value and a general degradation of natural resources; (3) Mega projects being implemented or proposed that will threaten the long-term conservation of the target values by an expected increase in habitat fragmentation, sedimentation, human population influx from outside the region, and impaired cultural practices of indigenous and Afro-Colombian communities. The key conservation challenges for the park are: (1) Inadequate facilities for staff and research support; (2) Weak coordination among the conservation institutions involved; (3) A lack of stakeholder engagement and involvement in resource management; (4) Insufficient budgetary resources allocated by the Ministry of Environment to comply fully with the mission and management, enforcement and evaluation.

Despite the support offered by SIMAC and the importance of coral habitats in the Colombian Pacific, weaknesses in protecting the MPAs remain. Among the most critical issues are: financial constraints to carry out scientific research projects; insufficient research on some basic issues in the formulation of conservation and management programs; and a lack of information on other conservation target values (such as soft bottom and rocky shore habitats), which may be closely related to coral ecosystems. Finally, climate change, the effects of which are beyond the direct control of MPAs, could have a significant impact in the future.

The three established MPAs with coral communities and reefs (Utría, Gorgona and Malpelo) together contribute to conservation, but face the challenge of moving beyond 'paper parks' (Rife et al. 2012) in order to reach effective conservation and sustainability goals. Building capacity for effective governance and monitoring, supported by scientific knowledge from research and academic institutions and environmentally-sound national development strategies, can help solve major problems in the conservation of coral habitats.

21.2.7 Ecuador

Protected areas in Ecuador are subject to the control and supervision of the Ministry of Environment of Ecuador (MAE), which determines their rules of management.

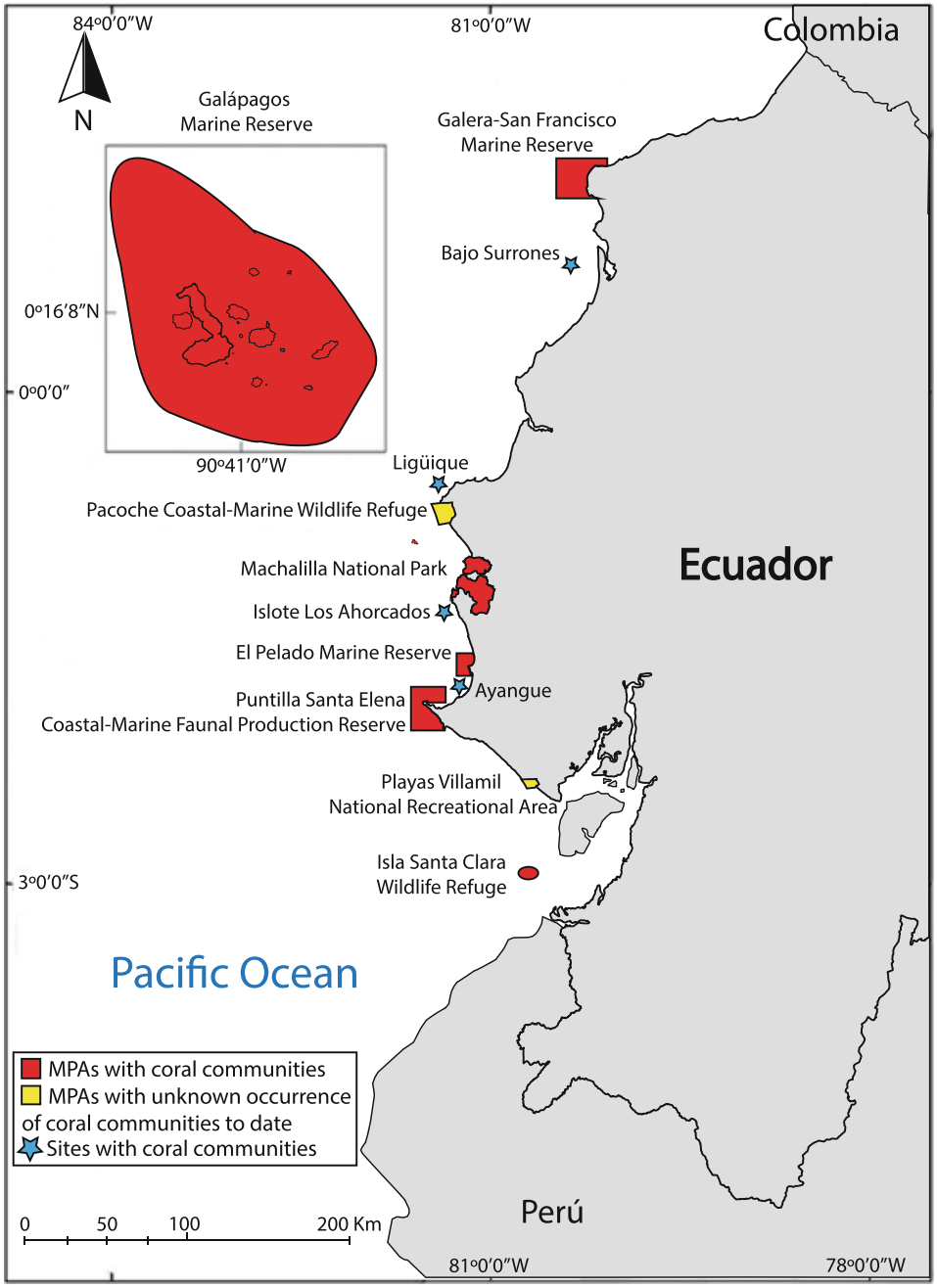

Fig. 21.7 Marine protected areas in Ecuador with or without coral communities (i.e., zooxanthellate scleractinian corals). In addition, sites outside protected areas with coral communities are shown (teal stars, not drawn to scale). MPAs with coral communities do not necessarily possess corals across all the reserve but coral formations have been identified at certain sites (see Figs. 5.24, 5.25, 5.29, and 5.30, Chap. 5). Pocilloporid corals have been reported for Isla Santa Clara Wildlife Refuge (René Espinoza, pers. comm.), and *Pocillopora damicornis* at Aconcito, located at Puntilla Santa Elena Coastal-Marine Faunal Production Reserve (Jesenia Zambrano, pers. comm.). Only the Galápagos Marine Reserve and the Machalilla National Park (including Isla de la Plata) are known to contain significant coral reefs. Map courtesy of Jael Martínez, with modifications by Juan Manuel Álava, Cecilia Sáenz, and Diana Moanga

Approximately 20 % of Ecuadorian territory, composed of 50 reserves, is within the bounds of protected areas. Of these, 14 protect coastal and marine environments (Hurtado et al. 2010) and include three marine reserves (Galápagos Marine Reserve, Galera-San Francisco Marine Reserve and El Pelado Marine Reserve, Fig. 21.7), five that contain both marine and terrestrial ecosystems (Machalilla National Park, Pacoche Coastal-Marine Wildlife Refuge, Puntilla Santa Elena Coastal-Marine Faunal Production Reserve, Isla Santa Clara Wildlife Refuge and Playas Villamil National Recreational Area, Fig. 21.7), and, six that exclusively cover mangals (Manglares Cayapas-Mataje Ecological Reserve, Manglares Churute Ecological Reserve, Manglares Estuario Río Esmeraldas Wildlife Refuge, Manglares Muisne-Cojimíes Wildlife Refuge, Manglares El Salado Faunal Production Reserve, and Manglares El Morro Wildlife Refuge) (Registro Official No. 202 2012, MAE 2014)

The Galápagos Marine Reserve (GMR) was named a UNESCO World Heritage site in 2001 (Danulat and Edgar 2002). Established in 1998 by the Organic Law on the Conservation and Sustainable Development of the Province of Galápagos (LOREG), it became the first Ecuadorian

protected marine reserve (Villarta 2013), and is currently the largest, covering 138,000 km^2 in area. The GMR has been effectively managed in general terms because it benefits from protection guaranteed by LOREG. The same applies to the legal and political framework since LOREG highlights the archipelago's needs of a consolidated vision for both the conservation of natural resources and sustainable development. An assessment of the GMR habitats has called attention to an increased concern for areas near fishing villages. It was also noted that areas requiring better management or mitigation strategies include coral habitats, rocky shores and reefs, macroalgal communities, and open water ecosystems (Luna et al. 2013).

The same year that GMR was created, different management measures were drafted to control fishing access. These measures were adopted to ban industrial fishing from the reserve and to establish a system of artisanal fishing licenses and permits (PARMA). Nevertheless, the implementation of this program was not sufficient to control the intense competition among fishers who seek to maximize catches in the shortest time possible. In 2009, through a consensus of the GMR's Participatory Management Board (PMB), and the Inter-Authority Management (AIM) agency, a new fisheries management system was adopted that included economic incentives for fishers, which slowed down the catch rate (Castrejón 2013). Since then several measures have been adopted for responsible management, for example establishing clear objectives for the mitigation of impacts to coral habitats, regulation of SCUBA diving, and sustainable fishing.

GMR coral habitats support numerous species, including rare and endemic taxa. In addition, these coral communities attract large numbers of transient species, including sharks, tunas, turtles, and dolphins. Unfortunately, coral habitats have been strongly impacted by El Niño events, where coral mortality in 1982–83 amounted to 95–99 % island wide (Glynn et al. 1988), with additional but less coral mortality in 1997–98, about 26 % island wide (Glynn et al. 2001). A significant effort to mitigate this loss was launched and supported by the 2004–2008 Darwin Initiative: 'Galápagos Coral Conservation: Impact Mitigation, Mapping and Monitoring'. The main purpose of this project was to work with the Ecuadorian government in establishing a coral biodiversity baseline, and preserving coral habitats. Results from the four-year initiative are: (1) an increased understanding of the biodiversity and vulnerability of coral communities, (2) the installation of permanent mooring buoys to protect corals from anchor damage, and (3) workshops and specialized training for personnel engaged in monitoring and protecting coral habitats (Dawson et al. 2009).

The Machalilla National Park (hereafter, Machalilla), is the only protected area in continental Ecuador that includes large terrestrial and adjacent marine areas. In addition, it contains numerous cnidarian species' assemblages. The coral reefs of Machalilla cover about 0.25 km^2 (25 ha), and represent the southern-most limit of known reef development on the eastern Pacific mainland. Although the number of endemic species is low, the faunal richness of Machalilla may exceed that of the GMR (Rivera and Martínez 2011). The best developed coral reefs are present on Isla de la Plata (see Chap. 5, Glynn et al., Fig. 5.25), Isla Salango and La Playita. In addition to anomalous oceanographic conditions such as El Niño, the main threats to the reef zones of these islands are trawling, and careless anchoring. Furthermore, both inside the park and along its buffer zone, several human communities depend on the available marine and terrestrial resources. General strategies have been established for in situ biodiversity conservation, including monitoring, enforcement of regulations, environmental education, and well-managed tourism (MAE 2007a, b). Nonetheless, the most serious risk to Machalilla's marine fauna is the irresponsible and uncontrolled exploitation by commercial and artisanal fisheries.

Following is a list of anthozoans proposed for special protection at Machalilla, based on an eco-regional assessment to establish a baseline of marine biodiversity: gorgonians (octocorals, e.g. sea fans), black corals (*Antipathes galapagensis* and *Antipathes panamensis*) and zooxanthellate (reef-building) corals of the genera *Pavona* and *Pocillopora*. The criteria considered in the selection of these taxa were: (1) degree of threat; (2) endemism, i.e. whether (a) a key species, (b) a foundation species, (c) a migratory species, (d) an umbrella species, i.e. a species that indirectly protects others by association, (e) a flagship species, i.e. a high profile species that indirectly benefits others by association; (3) their vulnerability to El Niño events; and (4) their habitat specificity (MAE 2007b).

There have been attempts to design management and conservation strategies of marine biodiversity at Machalilla, but there are legal conflicts between MAE and other public entities (MAE 2007b). As long as these conflicts remain unresolved, MAE cannot achieve an analysis of the fishing activity in the area. Another problem is that uncertainty exists concerning the boundaries of Machalilla; two maps exist with different geographic configurations. Despite this, some strategies were proposed in order to preserve the marine biodiversity of the park. First, commercial and semi-commercial fishing were banned throughout the area, and efforts have been made to ensure that vessels comply with the law to remain at a distance of eight miles from the protected area. Second, measures were implemented to control and monitor the catch of species for sale from all waters of the park, as well as to establish permanent or temporary restrictions on fishing. Finally, construction projects have been restricted on the coastline to avoid adverse effects (MAE 2007a).

The Galera-San Francisco Marine Reserve is located on the north coast of Ecuador within the Chocó region. This is the largest marine reserve on continental Ecuador,

comprising 546 km^2 and with a 37-km long coastline. There are a variety of marine habitats in the reserve, including: mangroves, estuaries, rocky reefs, and coral patch reefs. Within this reserve there are abundant gorgonian populations, several species of soft and stony corals, and the largest known black coral (antipatharian) population on the Ecuadorian continental shelf. The southernmost section of the reserve, "El Faro, is known to possess a significant coral formation" (Priscilla Martínez, pers. comm.). Importantly, it is noted that neighboring the reserve are seven local communities that depend mainly on fishing and agriculture for their livelihood; as a consequence, the above-named habitats are threatened from indiscriminate fishing, loss of habitat, deforestation, pollution, and human overpopulation. Some members of these communities, however, have played a key role in declaring the area a marine reserve. They have cooperated with the government and the NAZCA Institute in the development of conservation strategies (Zurita and Luna 2008; NAZCA 2013).

The NAZCA institute has been working for six years with local communities to promote conservation efforts in protected areas. The institute began analyzing different aspects of relevant communities, such as fishing activities and impacts, along with a socio-economic study of resident populations, and options for responsible management. The MAE, Muisne's township, and international institutions—The Nature Conservancy (TNC), The Lighthouse Foundation, The Jeffrey Cook Trust, Fundación Futuro Latino-Americano (FFLA), and ECOLEX—have all participated in conducting these analyses. Currently, the NAZCA institute continues working with the communities, promoting sustainable fishing, providing seafloor bathymetric data, and subtidal monitoring; these efforts are designed to help develop a new management plan to protect the Galera-San Francisco reserve.

El Pelado Marine Reserve (REMAPE), established on August 2012, covers 130 km^2 in area, and consists of rocky reefs with coral patches. This reserve harbors a variety of fishes and invertebrates, some of which are of high value to the local fishing and tourism activities. Several coral species classified by IUCN as of 'least concern' and 'near threatened', such as *Pocillopora damicornis, Pocillopora capitata*, and *Pocillopora eydouxi*, are present in the reserve. Species belonging to Category II of CITES, namely antipatharians and azooxanthellate scleractinian corals (the latter members of the family Dendrophylliidae) are also abundant (REMAPE Management Plan).

In addition to fisheries and tourism, other economic activities near REMAPE include agriculture and shrimp farming. Two of the greatest threats to the conservation of marine resources identified within REMAPE are the continuous use of prohibited fishing gear, as well as the intrusion of artisanal and commercial fishing boats (MAE 2013). Nevertheless, in order to define the uses within the protected area, and to ensure that the products and services are sustainable, a zoning scheme was proposed as a conservation tool where several uses are differentiated across six different zones (MAE 2013).

Similar in size to REMAPE, the Pacoche refuge (Coastal Marine Wildlife Refuge Pacoche) is located about 50 km north of Machalilla. It extends 6.4 km inland, and in the marine realm includes rocky reefs, sand beaches, and seamounts. It is unknown if coral habitats are present in this protected area. However, the southern-most reserve known to support scleractinian and gorgonian habitats is the Coastal-Marine Faunal Production Reserve Puntilla Santa Elena (Samaniego 2010).

A major disadvantage that both the Galera-San Francisco Marine Reserve and Machalilla face is an ambiguous and confusing legal framework. Current laws do not support the conservation and preservation of these protected areas. In addition, the existing laws are neither enforced by the government nor by local authorities (NAZCA 2013). With the exception of the GMR, none of the MPAs on continental Ecuador has specific guidelines to protect coral reefs or coral habitats. Protection at Machalilla is critical as this park contains the most extensive and diverse coral reefs on the continent.

Internationally, several nations have been considering conservation initiatives for mangroves and coral reefs in the Americas. In 2011, during the Ramsar Convention, the NAZCA institute represented Ecuadorian organizations relative to the conservation of coral reefs. One of the positive outcomes of the convention was the collective effort of nations to develop a strategic plan for the conservation, management, and sustainable use of the natural resources of mangroves and coral reefs across the equatorial eastern Pacific seascape (NAZCA 2011).

21.2.8 Chile

The coastal environment of Chile, which is strongly influenced by the Humboldt (Peru) Current, is characterized by temperate waters (Thiel et al. 2007). This restricts coral development to Rapa Nui (Easter Island) and Salas y Gómez Island, two sub-tropical oceanic islands located more than 3000 km west of the Chilean mainland (Fig. 21.8). Both islands are located on the Salas y Gómez Ridge (Gálvez-Larach 2009), are approximately 415 km apart, and belong to the same marine ecoregion. Numerous studies over the years have revealed their extraordinary biodiversity (Rehder 1980; Castilla and Rozbaczylo 1987; Disalvo et al. 1988; Parin et al. 1997; Mironov et al. 2006; Randall and Cea 2011). The global importance of these islands is now recognized, given their high levels of endemism. For example, 77 and 73 % of the biomass of the fish faunas of Rapa Nui

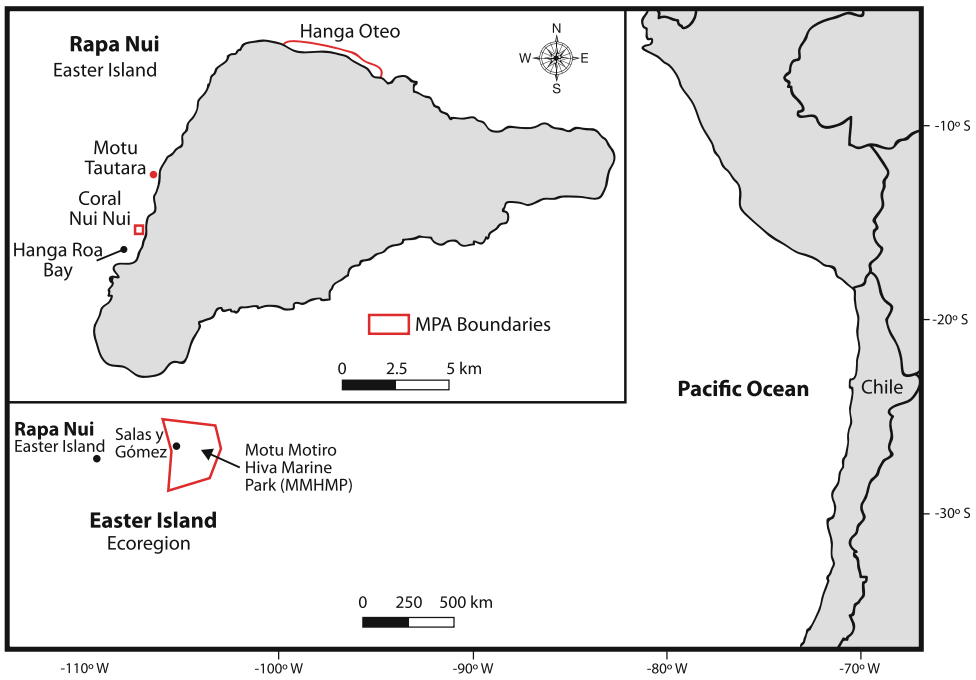

Fig. 21.8 Rapa Nui (Easter Island) and Salas y Gómez Island, Chile, MPA boundaries

and Salas y Gómez, respectively, represent endemic species (Randall and Cea 2011; Friedlander et al. 2013).

Conservation of the Rapa Nui ecoregion has not yet been fully implemented. In 1999, three small areas (Coral Nui Nui, Motu Tautara and Hanga Oteo) were designated as Marine and Coastal Protected Areas at Rapa Nui (Sierralta et al. 2011). Although these MPAs include coral cover, their main features are geological rock arches, caves, and lava platforms, which offer more scenic than biological value. Furthermore, these areas merely exist on paper and lack management plans.

Recent conservation initiatives have focused on developing the first marine reserve at Hanga Roa Bay, based on robust biological evidence, socio-economic considerations, and educational value (Figs. 21.8, 21.9; Gaymer et al. 2011, 2013). This site supports high coral cover. Development of the marine reserve has been delayed due to conflicts between Chilean authorities and the Rapa Nui community; the latter has requested more involvement in the creation of the marine reserve (Gaymer et al. 2014).

In contrast to Rapa Nui, the Chilean government created the Motu Motiro Hiva Marine Park (MMHMP) at Salas y Gómez Island and surroundings, which at 150,000 km^2 is one of the largest no-take MPAs in the world (Toonen et al. 2013; Wilhelm et al. 2014). The MMHMP was created to help protect biodiversity from the current threats of illegal fishing, which could alter the connectivity of marine life between the two islands, and impede potential replenishment of fish and other marine life through larval dispersal and recruitment to the depleted fisheries of Rapa Nui (Friedlander et al. 2013; Gaymer et al. 2014). Robust and extensive coral populations occur around Salas y Gómez Island and Scott Reef, and most likely on shallow unexplored seamounts. Unfortunately, no management plan exists for the MMHMP, resulting in only limited and sporadic enforcement by the Chilean Navy.

Although all coral species of Rapa Nui enjoy international protection by CITES, illegal trading within Chile is a common-practice. For instance, corals are still sold at Rapa Nui and on the Chilean mainland as decorative artifacts, and parts of various handcrafted products. While no coral mass-bleaching/mortality episodes have been reported at Rapa Nui or Salas y Gómez, bleaching of *Porites lobata* and *Pocillopora* spp. associated with heavy rains was reported

Fig. 21.9 Coral community dominated by *Porites lobata* and *Pocillopora* spp., Hanga Roa Bay, Rapa Nui (15 m depth). (courtesy of E. Sorensen, October 2011)

by Cea and DiSalvo (1982), and coincidentally during a period of elevated sea water temperatures (in the southern hemisphere) associated with a La Niña event (Wellington et al. 2001; Hubbard and García 2003). The latter bleaching event occurred when sea surface temperatures exceeded 26 °C. Local coral bleaching was also recently reported by Friedlander et al. (2013). The southern-most distribution of coral habitats at Rapa Nui and Salas y Gómez corresponds to subtropical waters that are several degrees cooler than those at equatorial eastern Pacific localities.

The most immediate threat to the health of Rapa Nui coral habitats is ostensibly the over-exploitation of large predatory fishes, including sharks, and fishing down the food web with the removal of herbivorous fishes (Mumby et al. 2012; Friedlander et al. 2013). It would be profitable to encourage future research to explore the trophic interactions of herbivores, macroalgae, and corals to determine if the decrease of fish herbivores may lead to a phase shift, with macroalgae outcompeting corals for space and eventually dominating benthic communities (Hughes et al. 2003; Friedlander et al. 2013).

Although conservation measures cannot prevent stresses related to climate change, such as coral bleaching, MPAs may increase community resilience by lessening the interactive effects of anthropogenic and climate-related stressors (Hughes et al. 2003). It would be advantageous for conservation research to focus on species' dispersal, coral bleaching, and overfishing, a critical triad of factors that can influence marine community structure and dynamics.

21.3 Regional Approaches

Regional approaches to management, such as networks and seascapes, have been applied recently to promote the consolidation of MPAs, improve management of marine areas by encouraging sustainable human activities, and improving the resilience of vulnerable ecosystems. In the ETP, the seascape approach seeks to achieve the protection and effective management of 2 million km^2 of key ecosystems and species within the core MPAs of Cocos Island (Costa Rica), Coiba Island (Panama), Malpelo and Gorgona Islands (Colombia), and the Galápagos Islands (Ecuador), including also nearshore islands on the continental shelf, and the promotion and application of conservation tools to improve management in the surrounding national waters of the four relevant equatorial ETP nations (Fig. 21.10).

The high species richness of these MPAs will help preserve the best developed coral habitats of the ETP, known for their high connectivity (see Chaps. 5, 16, Glynn et al., and Lessios and Baums respectively). Various coral-associated species, especially apex fish predators, sea turtles and marine mammals, move among these MPAs, using exclusive economic zones (EEZs, from mean low water mark to 200 nmi offshore) and coastal areas as feeding grounds, migratory routes and reproductive sites. In this context, coral communities are essential for providing habitat for the life cycles of diverse species vis-à-vis trophic sustenance, shelter, and aggregation sites.

The success of a regional approach for managing key ecosystems, such as coral communities and reefs, depends on active engagement with MPA managers and more effective consolidation, enforcement of fishing regulations, and the protection of species connectivity between different sites (Edgar et al. 2011). The ETP Seascape should be seen as an important step to reach broad conservation and management objectives that incorporate the initiatives of neighboring countries, and promotes better regional policies. The great ecological value of this seascape approach combined with its economic and cultural importance, is the reason why the ETP is on a short list of key oceanic areas termed "Hope Spots". This nomination should encourage managers and governments to improve and secure protection measures, and to foster appropriate management of the ETP and its critical role as a safeguard of the health of the world's oceans (http://mission-blue.org/hope-spots-new/).

21.4 General Overview

Anthropogenic threats differ from place to place. For instance, trawling and shrimp farming are destructive activities that damage not only Mexican Pacific reefs but also all marine ecosystems (Ezequiel et al. 2011). The following anthropogenic threats were, and still remain, prevalent in the ETP: illegal fishing, entanglement of lost nets, careless anchoring, diving related damage, extraction for handicrafts, agricultural runoff (fertilizers, pesticides), deforestation, pollution (sewage, industrial wastes), human overpopulation, and legal conflicts between public and governmental entities. The conflict between Chilean authorities and the Rapa Nui community regarding development of marine reserves is a clear example of how social conflicts can interfere with conservation goals (Gaymer et al. 2014). Conservation success stories inform us that the involvement of local communities, as well as local authorities, in the planning and creation of MPAs is critical to guarantee that short- and long-term conservation plans will succeed.

Two main strategies have been employed in the conservation of ETP coral habitats: (1) establishment of MPAs, and (2) implementation of legal tools and enforcement efforts. There are presently 45 MPAs extending along the Pacific Coast of tropical America (including oceanic islands), from the upper Gulf of California in the north to northern Peru just below the equator. MPAs with coral habitats cover a total area of 190,693.5 km^2 (Table 21.1). Mexico and Costa Rica

Fig. 21.10 Eastern tropical Pacific seascape connects EEZs of Costa Rica, Panama, Colombia and Ecuador (illustration courtesy of Conservation International)

rank first in terms of the number of MPAs, 11 in each country, and covering 16,891 and 4648 km^2, respectively. Panama has eight MPAs that include coral habitats with a total area of 7187 km^2. Ecuador possesses six MPAs (139,398 km^2), and Colombia and Chile four (10,202 and 150,021 km^2, respectively). El Salvador has one, covering 207 km^2.

According to IUCN MPA classification, five belong to category I (Strict Nature Reserve), 20 to category II (National Park), four to category IV (Habitat/Species Management Area), one to category V (Protected Landscape/Seascape), eight to category VI (Managed Resource Protected Area), and six are not yet classified (Table 21.1). Thus, the majority of MPAs allow some level of economic activities inside their areas, with the no-take zones being only a small fraction of the total protected area.

Established in 1963, the Cabo Blanco Absolute Natural Reserve in Costa Rica is the oldest MPA with coral habitats while the most recent, El Pelado Marine Reserve in Ecuador, was established in 2012 (Table 21.1). The greatest conservation impetus occurred in the 2000s, when 13 MPAs were established. This was followed by the establishment of 11 MPAs in the 1990s, and with fewer than 10 each in the 1970s and 1980s. During the first decade of the Twentieth Century there was mounting pressure to establish MPAs in the ETP with the goal of achieving the 2012 targets of the Convention on Biological Diversity: '*10 % of all marine and coastal ecological regions should be conserved in representative MPAs by 2012*; *by 2012, in the marine area, a global network of comprehensive, representative and effectively-managed national and regional protected area systems is established; and by 2012, all protected areas are effectively and equitably managed, using participatory and science-based site planning processes that incorporate clear biodiversity objectives, targets, management strategies and monitoring and evaluation protocols*' (http://www.cbd.int/sp/targets/rationale/target-11/).

ETP protection is vital, not only for its unique biodiversity and ecological resilience, but also because it harbors numerous coral habitats with many rare and endemic species. For continued protection, both national and international cooperation must occur.

21.5 Future Needs

Declaring MPAs does not in itself guarantee coral habitat protection and recovery. A new philosophical approach is needed to implement MPAs, taking advantage of all available scientific knowledge and the monetary investment that has been generated worldwide. In order to not only protect the biodiversity of these areas, it is also necessary to ensure that MPAs complement effective fisheries management outside their borders (Hilborn et al. 2004). Ideally, a successful MPA management plan should help increase the resilience of ecosystems and vulnerable communities to climate change and anthropogenic threats. We recommend that the managers of established and new MPAs enrich their knowledge of local communities and traditions, land-use, waste disposal, and other related activities. In order to assure the success of an MPA it is necessary to identify (as early as possible) the nature of all relevant stressors. Once identified, it is important to formulate and implement a mitigation plan. One of the reasons why MPAs of the ETP are not reaching their conservation goals is because of their complex and multilevel administration, i.e. a lack of efficiency. When decisions are made and resources are allocated by a central authority, there is better control of the budget, the staff is better informed of the day-to-day management, effective and transparent communication is easier to achieve, and coordinated interactions become simpler. Thus, the multilevel administration of some MPAs should be changed to a centralized administration. Bureaucratic sluggishness could perhaps be minimized by involving NGOs and academic entities in certain activities, such as assessment of MPA effectiveness, and updating management plans.

Research on the effects of sea warming and ocean acidification should continue on ETP coral communities, where disruptive ENSO thermal events also occur (e.g., Manzello et al. 2008, 2014). Further, national and international collaboration and support are essential to limit greenhouse gas emissions, the primary driver of Anthropocene climate change. Currently, coral habitats in the ETP are not sufficiently incorporated into MPAs. Regrettably, the majority of present-day MPAs have relatively small no-take zones. No-take zone areas should be expanded to benefit ecosystem recovery. Finally, it is apparent that ocean law and policy, which are fundamental to conservation, need to be up-graded and further developed in the ETP.

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