

# STATE OF THE CORAL TRIANGLE: Papua New Guinea



**CORAL TRIANGLE  
INITIATIVE**  
ON CORAL REEFS, FISHERIES AND FOOD SECURITY



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# Foreword

The Coral Triangle Initiative on Coral Reefs, Fisheries, and Food Security (referred to in this report as Coral Triangle Initiative [CTI]) was launched in 2007 as a multilateral partnership of the governments of Indonesia, Malaysia, Papua New Guinea, the Philippines, Solomon Islands, and Timor-Leste. The CTI recognizes the need to safeguard the coastal and marine resources of the seas that surround these countries, which together constitute a uniquely diverse and economically important region often referred to as the Coral Triangle. In 2009, these six countries adopted a 10-year, five-point CTI regional plan of action for improving management of the region's coastal and marine resources.

The State of the Coral Triangle (SCT) reports describe the current condition of coastal ecosystems—and their exploited resources—in each Coral Triangle country. As these are the first SCT reports to be published, they provide a baseline against which progress in improving and sustaining Coral Triangle marine resources can be measured. These reports also document and promote the commitments of Coral Triangle countries through elaboration of goals and a national plan of action for achieving sustainable use of marine resources within the region.

Through its technical assistance—Regional Cooperation on Knowledge Management, Policy, and Institutional Support to the CTI—the Asian Development Bank (ADB) helps (i) strengthen regional policy dialogue and coordination among the six Coral Triangle countries (CT6), (ii) facilitate CTI-wide information exchange and learning, and (iii) encourage policy and program development based on global best practices. As part of this technical assistance, ADB is publishing a number of CTI knowledge products, including the SCT report for each member country, and a regional SCT report that promotes regional and international understanding of current ecological, political, and socioeconomic issues in the region. Some of the CT6 have also published a detailed version of their report, which addresses sustainable resource management issues at the national level.

ADB is also helping three Coral Triangle Pacific countries (Papua New Guinea, Solomon Islands, and Timor-Leste) attain particular CTI goals, such as implementing the ecosystem approach to fisheries management, and establishing the Coral Triangle Marine Protected Area System and initiatives that help these countries adapt to climate change. Additional assistance is also being provided to Fiji and Vanuatu. While not technically CTI members, these countries border the Coral Triangle and share similar concerns.

Through these national and regional SCT reports, we hope to reach a wide audience that includes CT6 and those outside the Coral Triangle that benefit from the region's resources, whether through fisheries, shipping, or tourism, or as consumers of the great volume of fisheries products that originate from within the Coral Triangle, but are exported worldwide.



Xianbin Yao  
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A team of 14 authors from different backgrounds prepared this report, including Vagi Rei, Bernard Suruman, Job Opu, Paul Lokani, Augustine Mungkaje, Babara Masike, Anaseini Ban, Jane Mogina, Elizabeth Rei, Masio Nidung, Luane Liosi, Freddie Alei, Relvina Amos, and Junne Cosmas.

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# Executive Summary

Papua New Guinea (PNG) has a total land area of 462,000 square kilometers (km<sup>2</sup>), making it the largest Pacific island country. Its exclusive economic zone at 3.12 million km<sup>2</sup> is the world's second largest. The country's sparsely distributed population of only 7 million makes PNG's population density of approximately 9 people per km<sup>2</sup> the lowest in the South Pacific.

PNG's principal marine and coastal ecosystems include 13,840 km<sup>2</sup> of coral reefs, 4,200 km<sup>2</sup> of mangrove swamp forests, and extensive seagrass beds. The country is home to at least 500 species of stony coral, 1,635 reef-associated fish species, 43 mangrove species, and 7 seagrass species.

While PNG's extensive coastal reefs and offshore patch reefs show a high degree of biodiversity, information on the country's reef environment is limited—largely a result of limited research, monitoring, and management capacity. Nevertheless, some monitoring data are available from nongovernment sources.

Many of PNG's coastal areas are remote and isolated, making them difficult to access, much less manage. However, this isolation has resulted in one beneficial impact—it has restricted human activity in these areas. The negative impact of human activity on these isolated reef areas is thus minimal. In areas that are more accessible, environmental pressure on the country's reef resources includes (i) terrestrial sedimentation from poor land management practices; (ii) overfishing, particularly of invertebrates such as sea cucumbers; (iii) loss of predators at higher levels of the food chain; (iv) destructive fishing practices; (v) crown-of-thorns starfish outbreaks; and (vi) coral bleaching.

A customary system of tenure (*tambu*) applicable to fringing reefs and inshore fishing resources is widely practiced in many coastal communities. However, the practice of temporarily closing reefs under the *tambu* management regime is a practice now on the decline. Since global climate change will likely affect PNG's reefs, environmental stresses from human activity must be addressed if these reef areas are to remain resilient to climate change impacts.

PNG's coral reefs are mainly located on the country's north and east coasts, lying within an area widely referred to as the Coral Triangle. In addition to PNG, this area encompasses Indonesia, Malaysia, the Philippines, Solomon Islands, and Timor-Leste. Few marine protected areas exist in PNG. As a result, awareness of and support for marine resource conservation and management are mainly limited to areas in which nongovernment organizations are active, such as Kavieng and Kimbe Bay, and Madang and Manus provinces.

PNG's marine resources are an important source of economic livelihood in the extensive rural portions of the country's islands and coastal areas. They support a private sector fishing industry that is a significant source of government revenue. Fish is a major source of dietary protein, particularly in island and coastal areas, evident in the relatively high annual per capita fish consumption of coastal community residents, which is estimated at 53.3 kilograms.

Tuna and shrimp are the major commodities comprising PNG's commercial fisheries. Foreign vessels operating under access arrangements allowing them to fish in PNG waters accounted for more than three-quarters of the 2010 tuna catch, which totaled 799,000 tons. The present size of the current shrimp catch is unknown, although its annual value in recent years has averaged about \$10.5 million, which has increased since 2004, when about 600 tons taken were valued at \$4 million. The value of the bycatch of these fisheries in 2012 taken together is estimated at \$170 million.

Currently, the catch from subsistence fisheries totals about 50,000 tons, of which 30,000 tons are harvested from marine coastal areas, with freshwater sources accounting for the remainder. Tilapia and carp are farmed in 10,000–20,000 household ponds. In recent years, the rapid growth of coastal populations and consequent demand for cash income have increased coastal subsistence and artisanal fishing activity to such a degree that the sustainability of coastal fish stocks has become a serious concern.

Unsustainable fish harvesting practices and inadequate conservation strategies have endangered some marine species, most especially the freshwater dolphin, the dugong, three species of marine turtles, and three species of freshwater turtles. Similarly, mangrove forests are disappearing because of unsustainable rates of extraction, particularly in the Gulf of Papua.

One approach to conserving vital ecosystems currently being considered is payment for ecosystem services (PES). The rationale underlying PES schemes is that (i) ecosystems provide essential services that can be valued in monetary terms, (ii) users do not value these services if they do not pay for them, and (iii) owners or custodians of these ecosystems should be remunerated for ensuring that the ecosystem in question remains healthy enough to provide its services in perpetuity.

For example, PNG's shrimp fishery in part relies on mangrove forests as nurseries for juvenile shrimp. Thus, the annual licensing fee that shrimp fishers pay should include an additional PES component as remuneration for the nursery services mangrove forests provide. If a portion of this fee is used to pay the owners of mangrove forests, then these owners would be incentivized to ensure their sustainable management. While such PES schemes provide incentives for conservation without negatively impacting the government budget, the manner in which their proceeds are shared requires careful consideration. Owners of mangrove forests, in particular, must, at all costs, be disabused of the notion that the remuneration they receive is a one-off payment compensating them for destroying the mangroves they own.

In addition to fishing, economic activities such as tourism, offshore mining, and shipping can have a potentially negative impact on the marine environment. PNG's tourism sector is fragmented—the only subsector being developed is diving, which accounts for two-thirds of PNG tourist arrivals. Nevertheless, with improved management of the sector and appropriate

planning, the country's potential for developing its marine recreation and ecotourism subsectors is significant. Only one company is currently prospecting for minerals in offshore sites. However, environmental concerns in mining are significant, particularly relating to the discharge of pollution in the marine and terrestrial environment, as tailings from offshore mining are often deposited on land. PNG has 17 commercial ports and numerous small wharves and other landings. The National Maritime Safety Authority oversees all aspects of maritime safety and ensures that PNG's maritime safety obligations under international conventions are met.

Population growth rates in coastal areas are rising, as is the pace of coastal development. The rate of sea-level rise forecast for PNG suggests significant future degradation of coastal ecosystems from climate change, and in turn, disruption of economic activity dependent on them. Such disruption would negatively impact the economic livelihood of local residents, many of whom are disadvantaged by geography and distance, limited access to services, low-cash incomes, and limited alternative sources of income.

The contribution of PNG fisheries to national gross domestic product (GDP) is notably smaller than in other Pacific island countries. This suggests significant potential for increasing the total value of annual fisheries output and the contribution of fisheries to GDP. However, realizing this potential would require improvement of the overall management of PNG fisheries. This potential suggests that fisheries development and management programs would produce significant financial, economic, and social returns per dollar expended.

PNG has made significant progress in implementing its National Plan of Action (NPOA) for achieving the five goals of the Coral Triangle Initiative. Under Goal 1 on improving governance of priority seascapes, investment plans have been completed, along with arrangements for sequencing investments in a manner consistent with PNG's Vision 2050. Several international nongovernment organizations (NGOs) are undertaking research and conservation programs in areas relating to Goal 1.

Goal 2 is applying the ecosystem approach to fisheries management (EAFM). Draft policies that complement and support the EAFM have been formulated such as those relating to fish aggregation devices, community-based resource management, and protected areas. Further, some initiatives sponsored by government, NGOs, and other stakeholders implement some EAFM principles. However, such implementation lacked the positive impact it would have had, had these been guided by a straightforward EAFM policy that required management plans to focus on the ecosystem overall. On a positive note, many fisheries officers and community practitioners have been trained in EAFM principles, and a vessel monitoring system for the tuna fishery has been formulated, as has a draft national management plan for ornamental fishery. Under the Strategic Program for Climate Resilience, the Office of Climate Change and Development (OCCD) will help establish and operate community ecosystem-based fisheries on a pilot basis in vulnerable communities in Bougainville, East New Britain, Manus, Milne Bay, and Morobe.

Significant progress has thus far been achieved in fulfilling Goal 3, which is establishing and effectively managing marine protected areas (MPAs). A policy for protected areas has been drafted; a community-managed MPA network has been organized; and 11 locally managed marine areas (LMMAs) have been established, including an LMMA in Kimbe Bay in partnership with The Nature Conservancy, and LMMAs in Central, Madang, Manus, Milne Bay, and New

Ireland provinces. Once government formalizes the draft MPA policy, these LMMA will become part of the MPA system. An LMMA learning and training network has also been established.

Goal 4 is achieving measures for climate change adaptation. The OCCD in Central Province has assessed climate change vulnerability and various NGOs have carried out similar assessments at their respective project sites. The OCCD and several NGOs have also planted mangroves as a cost-effective coastal protection measure. A national workshop on mangroves was convened in 2011, and numerous training and awareness initiatives have been completed.

Implementing PNG's NPOA will require further strengthening of staff capacity at government agencies and NGOs, which should include the Department of Environment and Conservation; OCCD; and others such as those relating to agriculture and livestock, commerce and industry, information, and PNG ports. A central database of information relating to marine conservation and resource management should likewise be developed. Public awareness of the benefits of sustainable marine resource use will also be required. The successful implementation of PNG's NPOA would best be accomplished through regular public awareness programs linked to the plan. These initiatives will require funding that targets research, resource management, and public awareness.

# Abbreviations

ADB	–	Asian Development Bank
CTI	–	Coral Triangle Initiative on Coral Reefs, Fisheries, and Food Security (also referred to as Coral Triangle Initiative)
DEC	–	Department of Environment and Conservation
EAFM	–	ecosystem approach to fisheries management
EEZ	–	exclusive economic zone
GDP	–	gross domestic product
ha	–	hectare
km	–	kilometer
km <sup>2</sup>	–	square kilometer
IMO	–	International Maritime Organization
LMMA	–	locally managed marine area
LTN	–	Learning and Training Network
mm	–	millimeter
MPA	–	marine protected area
NCC	–	National Coordinating Committee
NFA	–	National Fisheries Authority
NGCC	–	New Guinea Coastal Current
NGO	–	nongovernment organization
NMSA	–	National Maritime Safety Authority
NPOA	–	National Plan of Action (of Papua New Guinea)
OCCD	–	Office of Climate Change and Development
PES	–	payment for ecosystem services
PNG	–	Papua New Guinea
UNCLOS	–	United Nations Convention on the Law of the Sea

# Introduction

The Coral Triangle is a marine expanse that straddles the Indian and Pacific oceans, and known to environmentalists to have extremely abundant marine life and significant biodiversity. The Coral Triangle includes some or all of the land and oceanic area of six countries: Indonesia, Malaysia, Papua New Guinea (PNG), the Philippines, Solomon Islands, and Timor-Leste. While it comprises only a scant 1.6% of the total area of the earth's oceans, the Coral Triangle is home to 76% of all known coral species; 37% of all known coral-reef fish species; 53% of the world's coral reefs; and the most extensive mangrove forests in the world, which are spawning and juvenile growth areas for tuna and other commercial fish species of global importance. These rich marine and coastal resources provide significant economic and social benefits—food, income, recreation, and culture—to the 360 million residents of the Coral Triangle, particularly the 120 million residents who live in or near the region's coastlines. These resources also protect the coastline and its residents from the damaging impacts of extreme weather events.

This report describes the biophysical characteristics of PNG's marine and coastal ecosystems, their governance under the prevailing legal and policy framework, and the institutional arrangements for ensuring compliance with the provisions of that framework. It also describes the socioeconomic characteristics of the populations these ecosystems serve, and the pattern of resource use of these populations. The report summarizes the threats to and vulnerabilities of these coastal and marine ecosystems, and describes how the country proposes to ensure sustainable use of these ecosystems in the future. From an operational perspective, implementing a national plan of action aimed at improving governance and managing marine resources will ensure future sustainable use of these ecosystems. Management of marine resources is to include an ecosystem-based marine resource management regime and adaptation to the negative impacts of climate change.

# Biophysical Geography

Papua New Guinea (PNG) has a total land area of 462,000 square kilometers (km<sup>2</sup>), making it the largest Pacific island country. Its exclusive economic zone (EEZ), at 3.12 million km<sup>2</sup>, is the world's second largest. The country's sparsely distributed population of only 7 million makes PNG's population density of approximately 9 people per km<sup>2</sup> the lowest in the South Pacific.

PNG occupies the eastern half of the island of New Guinea, and 700 surrounding islands on the western half of the island occupied by Indonesia. More specifically, seven-eighths of the country's total land area sits on the island of New Guinea, with offshore islands accounting for the remaining one-eighth. PNG remains heavily forested—its forest cover still exceeds 60%. Administratively, the country comprises 22 provinces, of which 15 have maritime elements, including the five island provinces of East New Britain, Manus, New Ireland, West New Britain, and North Solomons (now referred to as the Autonomous Region of Bougainville). The remaining 10 are mainland coastal provinces: Central Province, Gulf Province, Madang, Milne Bay, Morobe, Oro, National Capital Region, East Sepik, West Sepik (Sandaun), and Western Province. PNG's natural environment, marked by steep and variable topography, is highly diverse. The country's annual average rainfall exceeds 2,500 millimeters (mm).

PNG's relatively low population density is in part due to the country's rugged terrain, which complicates infrastructure development in general, and the establishment of transport and communication links in particular. The natural environment of many areas in the country remains relatively undisturbed.

## Land Mass

Geographically, PNG comprises four regions:

- (i) **Southern Region:** Hot and humid with generally low rainfall levels. Distinct dry and rainy seasons. A few dormant volcanoes are found in this region.
- (ii) **Islands Region:** Comprising islands that lie off the mainland, some of which have active volcanoes. This region is hot and humid. Its significant features include coral reefs, beaches, rich volcanic soil, and extensive marine resources.
- (iii) **Momase Region:** Topographically, this region ranges from open beaches to coastal swamps with dry savannah. Annual rainfall levels are 3,000–3,500 mm. A few active volcanoes are found in the region.
- (iv) **Highlands Region:** This region comprises several large open valleys with warm days and cold nights. Annual rainfall levels are 3,000–4,000 mm resulting in significant cloud cover, fog, and afternoon rain.

## Meteorological Features

Three major climatic systems influence PNG's weather patterns: (i) the Intertropical Convergence Zone, which passes over the region twice a year, its major influence occurring in January–April during which cyclones often occur, accompanied by heavy rain and high winds; (ii) the Trade Winds, which dominate the weather pattern in May–August; and (iii) the northwest monsoon dominating the weather pattern from December to March, with the southeast monsoon occurring from May to October. The overall impact of these climatic systems is a dry season from May to October, and a rainy season from December to March.

The average temperature in PNG's coastal areas ranges from 23°C to 32°C, though the highlands are significantly cooler, with temperatures ranging from 11°C to 25°C. While the country's average annual rainfall is 2,500–3,000 mm, some districts receive more than 9,000 mm, while others, such as Port Moresby, receive less than 1,000 mm on average.

## Ecological Features

PNG's remarkable topography includes mountains 4,500 meters in elevation, lowland rain forests, savannahs, and swamps that extend for hundreds of kilometers along coastal plains. Its coral reefs, mangrove forests, and deltaic wetlands are home to some of the earth's most diverse ecosystems (Nicholls 2004). In all, the country comprises six major biogeographical areas: (i) coastal and oceanic areas, (ii) deltaic plains, (iii) lowland forest areas, (iv) lower mountain forest areas, (v) upper mountain forest areas, and (vi) grasslands.

PNG's known species comprise 20,000 vascular plants, 197 amphibians, 300 reptiles, 762 birds, and 71 marsupial mammals. The country's marine species include more than 500 stony coral species, nearly 200 marine and freshwater decapod crustacean species, and more than 3,000 fish species. The diversity of PNG's flora is significant—it includes 3,000 orchid species and 43 species of mangroves.

## Hydrological Features

PNG's major rivers are the Fly (1,200 kilometers [km] in length), the Sepik (500 km), the Purari (233 km), the Markham (170 km), and the Leron (76 km). The country has 5,383 lakes, 22 of which have a surface area of more than 1,000 hectares (ha). PNG's major lakes are Lake Murray (64,700 ha), Chambri Lake (21,600 ha), and Wisdom Lake (8,590 ha).

## Ocean Currents

Because PNG waters lie in the Western Equatorial Warm Pool, there is significant international interest in studying the country's air–sea interactions, which include the global impacts of the

El Niño–Southern Oscillation. During the 1980s, the Western Equatorial Pacific Ocean Circulation Study (Lindstrom et al. 1987) described the major ocean currents and upper ocean structure that affect PNG’s climate. This study was followed by the Coupled Ocean–Atmosphere Response Experiment (Godfrey et al. 1998).

During the southeast monsoon, which dominates PNG’s weather from April through November, the Southern Equatorial Current traverses the Coral Sea and forms a northern branch where it meets northeastern Australia, where the New Guinea Coastal Current (NGCC) originates. The NGCC flows around and through the Louisiade Archipelago to PNG’s southwest, and then resumes its flow toward the Bismarck Sea through the Vitiaz Strait. The northern branch of the Southern Equatorial Current generally flows past Solomon Islands, and can either enter the Bismarck Sea through St. Georges Channel or Ysabel Channel from the north.

During the northwest monsoon, the NGCC and the northern arm of the East Australian Current can reverse and flow southeast through Vitiaz Strait along the northern coast of Papua New Guinea. While the two studies focused on major circulation systems and pathways impacting the area around PNG, little is known about the manner in which ocean water circulates within the Bismarck Sea. One navigational chart (AUS 4622) refers to the possibility of a counterclockwise eddy.

Unfortunately, the high humidity in the region in which PNG is located often causes cloudy conditions, negating the possibility of studying oceanic circulation patterns by remote sensing. The Bismarck Archipelago is known to block the major flow of the Southern Equatorial Current. As a result, oceanic circulation patterns other than the major currents tend to be complex, with recirculation occurring in the lee of the region’s island archipelagoes, particularly when the southeast monsoon predominates.

## Coastal and Marine Features

PNG is surrounded by three major oceanic bodies—the Bismarck Sea to the north, the Solomon Sea to the north and east, and the Coral Sea to the south and east. A fourth major oceanic body of water, the extensive Gulf of Papua, lies between PNG and Australia.

Because of PNG’s extensive 17,000-kilometer coastline, and its significant EEZ comprising 3.12 million km<sup>2</sup>, the country is home to a wide variety of marine environments, ranging from tidal wetlands and estuaries to deep ocean basins. PNG is renowned for its significant marine biodiversity and pristine coral reefs and coastal environments. The country’s waters extend well beyond coastal shelves, and include deep ocean basins that remain almost completely unexplored.

PNG’s principal marine environments (Sekran and Miller 1994, based on Agardy and Pernetta, 1993) include the following:

- (i) barrier dunes and associated coastal lagoons;
- (ii) deltaic floodplains and estuaries;
- (iii) mangroves;
- (iv) reefs (fringing reefs, patch reefs, and barrier reefs), reef walls, and continental slope drop-off areas;

- (v) rocky shorelines;
- (vi) sand and mud shorelines and intertidal flats;
- (vii) seagrass beds; and
- (viii) seamounts.

Except for the seamounts and continental slope, these environments are coastal, or are located on the continental shelf (e.g., barrier reefs).

## Coral Reefs

Most of PNG's coral reefs are of the fringing or patch type, with extensive barrier reefs occurring only along the country's southern coast (e.g., the Motuan coastline), the Louisiade Archipelago, and around the East Cape on the eastern coast. Fringing and patch reefs predominate along the northern coast (e.g., Madang) and the New Guinea islands. Dilution of seawater with freshwater (i.e., salinities of less than 35 parts per thousand) tends to suppress coral growth, as does turbidity of the aquatic environment, causing corals to be noticeably absent in the mouths of major rivers. Together, dilution of seawater and turbidity influence the distribution of coral.

Several recent studies have confirmed the significant diversity of corals on PNG's reefs. In all, PNG waters are probably home to more than 500 species of stony corals. In 1994, the Nature Conservancy's Asia and the Pacific program funded a rapid ecological assessment of the coral reefs of Kimbe Bay in West New Britain Province, which was performed by a team of scientists from Australia, PNG, and the United States (Holthus 1994). This study surveyed 78 sites in all, collected detailed information on the degree of abundance and distribution of coral species at 39 sites (Maragos 1994), and found 345 species of coral at these 39 sites.

This finding corroborates those of other detailed surveys conducted in Australia, Indonesia, Japan, the Philippines, and elsewhere in PNG. At the time, this number of coral species was among the highest ever reported in such a small area (Maragos 1994). In fact, two-thirds of the coral reefs surveyed showed high levels of live reef cover (in excess of 50%), and many individual sites had rates of coral cover exceeding 75% (Holthus and Maragos 1994). Such a finding suggests that the coral reefs at these locations were in a near-pristine state at the time the study was performed.

Similarly, a report on the Madang Locally Managed Marine Area Network prepared by Wetlands International (Jenkins 2002) assessed the diversity of coral reef fishes at this location, indicating the degree of biodiversity at the coral reefs in the area. The report noted the local, national, and global importance of the biodiversity of reef fish within the Madang Marine Area Network.

Likewise, in 1998, an assessment report on marine conservation needs of Milne Bay Province sponsored by Conservation International reported more than 429 species of coral fauna, including 10 new species (Seeto 2000)—the greatest degree of coral diversity to date. This number of species exceeds that of Australia's entire Great Barrier Reef, and is equal to the degree of coral fauna diversity found in Indonesia and the Philippines, both previously believed to be the world's most species-rich coral habitats.

Such reports confirm the global environmental significance of PNG's coral reefs. The country's reefs are equally important to local residents, as coral reef fisheries are a primary source of food

and income for many PNG coastal communities. Reefs contain nursery and feeding habitats for many marine species. If managed appropriately, reefs could be a primary and sustainable source of marine resources. Reefs protect local residents from physical damage caused by high waves and storm surge, and the shoreline from erosion. Moreover, the sheltered reef lagoons located in the lee of coral reefs are habitats for a wide variety of coastal species, seagrass beds, and mangrove stands that further stabilize the shoreline by anchoring sediment.

### Seagrass Beds

Seagrass beds are common in reef flats and coastal lagoons, particularly those located close to small river estuaries that give a constant but limited supply of fine silt and mud sediment to the lagoon floor. However, excessive concentrations of suspended sediments in lagoon environments where waters are turbid appear to inhibit seagrass growth.

PNG's coastal lagoons are home to a wide variety of seagrass species, the most commonly encountered being turtle grass (*Thalassia hemprichii*), *Enhalus acoroides*, and species of the genus *Halophila*. Seagrass beds are an important habitat for many marine invertebrate species and juvenile fish. Their root networks help anchor the fine silt in which they grow; and provide a stable substrate for many species of marine worms, themselves the basis of a complex food chain that extends throughout the seagrass community. Seagrass beds are likewise vital to the survival of the dugong, a large herbivorous mammal that inhabits PNG waters and feeds almost exclusively on seagrass.

The dugong is so endangered that it appears on the Red List of Threatened Species published by the International Union for Conservation of Nature. Formerly widespread in Southeast Asia's tropical waters, it is now nearly extinct, most probably because of habitat loss, although indiscriminate hunting during the first half of the 20th century significantly depleted its numbers. Mainly located in the Papuan Lagoon in the southwest part of the country, PNG's dugong population is of global environmental significance, as it is likely the world's largest remaining population.

### Mangroves

Mangroves are common in PNG's coastal regions, with particularly extensive stands in and around the deltas of major rivers, especially along the southern coast. The mangrove stands' close-knit lattice of aerial roots stabilizes the mud and silt sediments they inhabit, and provides a sheltered environment in which silt deposits predominate. More importantly, the mangrove's tough, securely anchored root lattices protect the shore against erosion from storms and high waves. Notably, the water is significantly less turbulent just a few meters inside the outer edge of mangrove stands. At greater distances from the sea inside the mangrove stand (which may be hundreds of meters wide), still-water conditions prevail, more or less, regardless of the state of turbidity of coastal seas.

Significant changes to the erosion-deposition regime along coastlines due to loss of, or substantial damage to, mangroves can have profound effects on the coastal ecosystem, the use of its natural resources, and the stability of coastal infrastructure. The mangrove's root lattice and the organic matter and nutrients in river mud and silt, which are replenished daily by the ebb and flow of tidal currents, provide rich and productive habitats for numerous invertebrate

species, making these waters ideally suited as nursery habitats for many marine and estuarine species. Further, the juvenile stages of several commercially important PNG fish species live in these rich and sheltered mangrove waters.

Mangroves are susceptible to changes in coastal flow regimes, which in turn affect the amount and composition of local sedimentation. For example, excessive sedimentation can suffocate the roots of many mangroves, causing growth to cease and, ultimately, death of the plant itself. Conversely, insufficient sedimentation rates cause the amount of organic matter entering the ecosystem to fall below that necessary for replenishing the sediment and organic matter naturally lost through circulation. This results in falling sediment nutrient concentrations that inhibit mangrove growth. Further, if sediment nutrient concentrations fall below a critical threshold, the roots can be exposed, making them susceptible to damage or disease. In extreme cases of sediment loss, structural failure of the plant occurs, as the soil in which it is anchored becomes insecure. Ultimately, falling sedimentation rates result in widespread loss of mangroves, which in turn increases exposure of the coastline to the erosive effects of storm surge and high waves.

PNG's major mangrove habitats depend on the depositional environments associated with the country's major rivers, including the Markham, Ramu, and Sepik rivers along the northern coastline of the PNG mainland; and the Fly, Kiokori, Purari, and smaller rivers such as the Brown and Vanapa rivers and the Kemp Welch River, all of which are located on the country's southern coast (Paijmana and Rollet 1977, Petr 1983, Bualia and Sullivan 1990, Pernetta and Osborne 1990, Woodroffe 1992).

## Geological Features

Geologically, the island of New Guinea is part of the crustal elements of (i) the Australian Plate, (ii) its associated continental and relatively stable land mass, Australia; and (iii) the deep ocean basin associated with the Pacific Plate to the north (Löffler 1977). In geologic terms, the island of New Guinea is relatively young. Movement of the Pacific and Australian plates results in some subplate movement along the region's fault lines, which originate in the Solomon Sea, pass through Lae and Ramu, and on to the coast in Wewak (East Sepik Province) and Aitape (West Sepik Province) on the northern coast of PNG. These subplate movements include movements associated with the New Britain Trench (Solomon Sea) and the Bismarck Subplate near the Manus Basin.

The principal processes responsible for the genesis of the various landforms and habitat types include (i) tectonic processes (quaternary sea level changes, weathering, erosion, and terrestrial runoff); (ii) oceanographic and climatic processes; and (iii) biogeographical processes.

# Governance

**E**nvironmental sustainability is enshrined in the Constitution of Papua New Guinea (PNG), the Preamble of which states that “*we declare ... PNG’s natural resources and environment to be conserved and used for the collective benefit of ... all, and to be replenished for the benefit of future generations.*” There is thus a constitutional basis for PNG’s legislative framework for managing the nation’s natural resources, which include its oceanic resources. However, the governance structure for managing the country’s oceanic resources is not explicitly laid out in the applicable legislation.

While not immediately apparent to the casual observer, the lack of basic support services in remote communities is a major constraint in managing marine resources. In fact, the country’s remote communities—many of which are found in the maritime provinces or on atolls—lack basic health and educational services, and more importantly, a reliable supply of food. Erosion of land by climate-related events damages or reduces the agricultural base, and further affects the communities’ food supply. The resulting unreliable food supply has profound implications for sustainable management of marine resources, as it leads to their unsustainable exploitation. From a political perspective, lack of food security and damage from climate-related events are inevitably given priority over long-term management of marine resources. All of these factors taken together constrain PNG’s ability to fulfill its long-term marine resource management objectives.

## International Legal Framework

Key to the formal international legal framework for protection and sustainable use of the oceans are (i) the conventions of the International Maritime Organization (IMO), and (ii) the United Nations Convention on the Law of the Sea (UNCLOS). In addition, a relatively large number of environment- and fisheries-related international law instruments and regional agreements are currently in place, as well as numerous related codes, guidelines, and resolutions. This latter set of instruments comprises what is referred to as international “soft law,” since sovereign states cannot be compelled to comply with their provisions. In sharp contrast to such unenforceable soft law instruments, “hard law” instruments such as treaties are enforceable internationally, in that international bodies can compel compliance by sovereign states.

Despite their seeming ineffectiveness or innate weakness, soft law instruments play an important role in promoting environmental sustainability, in that sovereign states that endorse them have made a public, formal commitment to comply with the provisions of the instrument concerned. Their mere existence—and ultimately, their endorsement—paves the way for eventual ratification of hard law instruments such as treaties.

Soft law international instruments call on governments to ensure the long-term security of the environment, particularly the marine environment, such as (i) the Rio Declaration on the Environment; (ii) the Code of Conduct for Responsible Fisheries sponsored by the Food and Agriculture Organization (FAO) of the United Nations (UN); and (iii) the UN Framework Convention on Climate Change. PNG has ratified some of these international law instruments and stands committed to their implementation. In some cases, domestic reforms are required to make existing legislation consistent with such international obligations.

In the end, such international commitments convey the message that environmental sustainability is a precondition to the well-being of future generations. Appropriate steps must be taken now to ensure the food and livelihood security of future generations.

## Maritime Border Treaties

PNG has ratified several maritime border agreements with Australia, Indonesia, and Solomon Islands. A further agreement with the Federated States of Micronesia has been signed, but not ratified. These maritime border agreements govern relations between PNG and neighboring countries, particularly with regard to marine resources. Operationally, they include a call for cooperation in certain areas, including protection of the marine environment, security, and surveillance.

PNG's agreements with Australia and Indonesia provide for a system of traditional border crossings between these countries; and call for protection of traditional inhabitants and livelihoods, and the general protection of jurisdictions located within the areas addressed by the agreement concerned.

Protection and preservation of the marine environment is addressed by many formal arrangements and agreements. The Arafura and Timor Seas Ecosystem Action Program—to which PNG is a signatory—complements the requirements of Article 123 of the UNCLOS that relates to semi-enclosed seas.

## Key National Legislation

Goals 3 and 4 of PNG's National Constitution obligate the government to ensure that the environment is sustained for future generations. The Environment Act and Fisheries Management Act provide the regulatory framework for implementing these goals, as does other legislation.

As a general rule, subsequent to PNG's ratification of international conventions or agreements, the government must, according to the National Constitution, implement the requirements of the conventions into national laws or policies in a manner that ensures the conventions or agreements concerned have the force of (domestic) law.

The following national laws address governance of PNG's oceanic resources:

- (i) Customs Recognition Act,
- (ii) Environment Act,

- (iii) Fisheries Management Act,
- (iv) Land Dispute Settlement Act,
- (v) Mining Act,
- (vi) National Maritime Safety Authority Act,
- (vii) National Seas Act,
- (viii) Oil and Gas Act,
- (ix) Organic Law on Provincial Governments and Local-Level Governments Act,
- (x) Ports Authority Act, and
- (xi) Village Courts Act.

Existing legislations must be amended to make PNG national laws consistent with international standards and requirements.

## Legal Implications for Development of Oceanic Resources

Setting the standards against which the degree of sustainable development can be measured is an important aspect of governance of oceanic resources. However, to be effective, such standards require a robust environmental management regime. A vital part of such a regime is a set of regulations that either permit or prohibit activities that impact the sustainability of marine resources. Many of these requirements should reflect UNCLOS-based direct obligations, which include duty of due care as it relates to protection of the marine environment. Such duty of due care emphasizes a precautionary approach to marine resource management, and at the minimum, an appropriate environmental impact assessment regime.

However, in the case of PNG, adopting precautionary principles is likely to be ineffective unless it is coupled with continual monitoring and assessment of the sustainability of the country's marine environment. This in turn would require strengthening the existing legal and regulatory regime under the national legislation that addresses management of the marine resources.

For example, the current Environment Act (2000) could be strengthened by including environmental impact assessments and best practice standards that are consistent with the standards for maritime economic activities set out by the UNCLOS, particularly those relating to seabed mining.

Links between PNG's various national laws that address marine resources are likewise important in fulfilling the country's international commitment to sustainable management of the marine resources. This would require integration of the requirements for obtaining approvals or permits allowing particular marine-based economic activities as set out respectively by the Environment Act, the Fisheries Management Act, the Mining Act, and the Oil and Gas Act. Such integration would help avoid the potential conflicts inherent in the content of these acts in their present form. For example, existing legislations relating to mining or other economic activities that could negatively impact marine protected areas (MPAs) should be amended in a way that either limits or prohibits such activities in MPAs already declared by other legislation.

Guidelines for resolving disputes among stakeholders could also be put in place to ensure consistency in dispute resolution, particularly in accommodating the rights of various users.

Likewise, assessment of the impacts of development projects on local residents could be made an essential step in project formulation and approval. However, care must be taken to ensure that legal and regulatory frameworks are appropriately amended to ensure the operational viability of such changes. The above notwithstanding, PNG's current major challenge is to identify the marine areas in which environmental protection is a precondition to sustainable development of the fisheries resources.

## Policies and Gaps

The UN Millennium Development Goals—particularly those relating to environmental sustainability and poverty alleviation—are relevant to sustainable exploitation of PNG's marine resources, and sustainable development of coastal communities. Relevant policies and gaps are summarized below.

**Policies.** Government policies already in place impact one another such as the Environment Policy, the Population Policy, and the Poverty Alleviation Policy, which call for ensuring food security for future generations by reducing environmental stress that is driven by population growth.

**Papua New Guinea's Vision 2050.** The vision calls for food security, poverty reduction, and sustainable environment; and goals include promotion of MPAs.

**Papua New Guinea Development Strategic Plan 2010–2030.** The aspects of the strategic plan relating to the development of PNG fisheries focus on sustainable management of commercial fisheries. While this focus is admirable, the plan is silent on how this goal is to be accomplished from an operational perspective. This is reflected in the lack of any link between the strategic plan and PNG's international obligations such as the Convention on Biological Diversity, FAO's Code of Conduct for Responsible Fisheries, and the UN Framework Convention on Climate Change (UNFCCC). In its current form, the strategic plan fails to establish a link between establishing MPAs and ensuring food output as it relates to fisheries. For example, no link exists between the declaration of MPAs and declining stocks of both bigeye and yellowfin tuna in PNG waters.

Relevant policy gaps include the following:

- (i) an integrated national ocean policy for PNG that is consistent with the Pacific Islands' Regional Ocean Policy adopted in 2004;
- (ii) a seabed policy that builds on current seabed extraction-related development, particularly the agreement concluded with Nautilus Minerals in 2012 permitting mining of PNG's seabed;
- (iii) dispute resolution guidelines for resolving conflicts between users of oceanic resources;
- (iv) integrated environment planning and management guidelines for governing the extraction of offshore marine resources, particularly through exploiting fisheries and mining seabed resources, and extracting oil and gas;
- (v) guidelines for development in coastal zones, including coastal communities; and
- (vi) long-term waste management guidelines for land-based activities that affect the marine environment.

Court precedents suggest that while the ocean is communal property and that no one should own it, it must be managed for the general public interest, which can only be done by the national government. Such goals suggest some limitations on the rights of customary users of marine resources, and PNG's coastal communities in particular. However, the government has a duty to address the needs of these communities, and provide proper documentation of customary fishing rights to strengthen the communities' marine tenure systems over the long term.

In its current form, the Organic Law on Provincial Governments contains legal gaps and inappropriate power-sharing arrangements. In particular, this law does not articulate the manner in which government agencies at various levels should address issues on marine resource management.

It is ultimately the government's responsibility to (i) plan for, and manage the marine resources to prevent its degradation over time; (ii) achieve consistency in laws, policies, regulations, and standards promulgated for this purpose; and (iii) strengthen environment planning and management, and environmental impact assessment procedures to ensure sustainable management of marine resources.

## International Obligations Regarding Coastal Areas

Various international conventions, such as the Convention on Biological Diversity and the Ramsar Convention on Wetlands, contain provisions relating to the rights of governments. The rationale underlying such rights is that they are a precondition to ensuring that long-term measures protecting fragile marine ecosystems and ensuring their sustainability are put in place.

As a State Party to the Ramsar Convention, PNG is required to safeguard and protect vulnerable wetland areas, which include areas located in rivers, delta plains, and estuaries; and along the country's coastline. However, in the modern context in which users other than local communities have rights to the use of this resource, traditional wetland management practices alone are insufficient to achieve sustainable development. Long-term protection of marine resources ultimately requires that governments integrate into national planning the needs of both large-scale users and the communities that use these resources. For example, if commercial fishing is to share use of the fishery resources with local communities, the government must set a total allowable catch for each fishery that somehow must be shared by both sets of users. This total allowable catch and its division among artisanal and commercial-scale users must be backed both by the legal authority to compel users' compliance, and the credible threat of sanctions for noncompliance. However, even setting an appropriate total allowable catch requires sufficient knowledge of the demands of commercial fishing and those of artisanal fishers.

## Enforcement

The authority for enforcing fisheries regulations is spread across the government agencies listed below. In some cases, this authority is granted by administrative edict, while in others it derives from national legislation.

- (i) Border Control Authority/Department of Interrelations
- (ii) Customs Bureau
- (iii) Department of Environment and Conservation
- (iv) Department of Foreign Affairs
- (v) Department of Petroleum
- (vi) Mineral Resources Authority
- (vii) Mineral Resources Policy and Geohazards
- (viii) National Fisheries Authority
- (ix) National Mapping Bureau
- (x) National Maritime Safety Authority
- (xi) Office of Climate Change and Development
- (xii) Ports Authority
- (xiii) Surveyor General Office
- (xiv) Universities and other learning institutions for capacity building in matters relating to development of oceanic resources

Conflicts in enforcement authority typically arise when multiple government agencies are given legislative authority to enforce a particular aspect of marine resource management. Further, some government agencies are unfamiliar with others' offshore enforcement powers, and may not even be aware that they are impinging on another government agency's enforcement authority. For the most part, this is due to misapplication or misunderstanding of existing law. For example, in recent years, the PNG Customs Bureau has on occasion detained offshore fishing vessels operating in PNG waters, when in fact the National Maritime Safety Authority (NMSA) has the authority to detain such vessels.

Typically, IMO conventions authorize officers of the NMSA to board and inspect vessels for purposes of compliance with IMO conventions. In fact, PNG's Merchant Shipping Act specifies the procedures to be followed when NMSA officers board and inspect such vessels. However, the Western and Central Pacific Tuna Convention authorizes officers of the National Fisheries Authority to board and inspect such vessels. Further, PNG's Fisheries Management Act allows the National Fisheries Authority officers to board and inspect vessels, both in PNG waters and on the high seas.

Cross-jurisdictional enforcement is an efficient means of resolving such conflicts. However, this would require legislation that appropriately addresses cross-jurisdictional enforcement. The relevant officers of the agencies concerned would need to be trained in the exact division of responsibilities under such cross-jurisdictional arrangements.

Compliance with applicable laws, regulations, and standards would require appropriate border control and protection measures, particularly in remote border areas such as Daru in Western Province and Vanimo in West Sepik Province; in Kavieng, Manus, and Milne Bay provinces; and the Autonomous Region of Bougainville.

## Future Developments

PNG's continuing economic development will inevitably increase environmental pressure on the marine resources. Long-term sustainable development of marine resources will require government interventions. However, the range of such interventions available to government is, in fact, wider than is generally appreciated. "Blue carbon" protection of marine ecosystems provides one such example. The term "blue carbon" refers to the carbon stored in coastal and marine ecosystems. Protection of such ecosystems is necessary to prevent this stored carbon from being released into the ocean and atmosphere, which would contribute to global climate change.

Exploitation of PNG's liquefied natural gas resources poses many sustainable development challenges, such as long-term impacts on the livelihood of local communities, putting in place measures for avoiding any adverse impacts on the marine environment, and even advance planning for environmental disasters such as oil spills. The discovery of gas in the Gulf of Papua suggests that deep-sea oil and gas extraction in PNG waters is financially feasible, and that further exploration in other areas within PNG's exclusive economic zone may be warranted. Putting such protections in place in advance of their use is thus likely a prudent course of action.

Under an agreement signed with the government, Nautilus Minerals is to undertake deep seabed mining in the Bismarck Sea. In this regard, guarding against adverse long-term environmental impacts will require an appropriate environmental impact assessment and continual monitoring by the government.

Claiming extended continental shelf areas is a distinct possibility for PNG, which would open up new areas to further marine resource exploitation. However, depending on future recommendations by the UN Commission on the Limits of the Continental Shelf, such a claim on PNG's part would probably require joint work arrangements, common management areas, and contractual resource arrangements with neighboring countries. PNG could best respond to this possibility by formulating guidelines for dispute settlement regarding resource extraction rights in PNG waters.

# Socioeconomic Characteristics

The National Census 2000 of Papua New Guinea (PNG) reported a national population of 5.1 million, with an average growth rate of 2.43%. Currently, the population is estimated at 7 million, with an urbanization rate of 16%. Life expectancy is currently estimated at 63.1 years—65.3 years for females, and 61.1 years for males.

PNG is home to more than 1,000 ethnic groups. New Guinea Papuans account for the largest share of the population, followed by New Guinea Melanesians. Christianity is practiced by 97% of the population, while the remaining 3% practice traditional beliefs. Table 1 presents socioeconomic indicators for PNG.

**Table 1 Socioeconomic Indicators for Papua New Guinea**

Variable	Magnitude	Source
Population (2011)	7,013,829	World Bank
Population growth rate (2011)	2.2%	World Bank
Population living within 10 km of a coastline	1,612,080 (23%)	Center for International Earth Science Information Network (2007)
Persons employed in fishing and aquaculture (2000)	16,000	World Resources Institute
Annual fish production from marine areas (2009) (t)	216,361	FAO (excluded aquatic plants, and animals and fishes from inland waters)
Annual per capita fish consumption (average for 2005–2007) (kg)	13	Bell et al. (2009)
Fish as % of total animal protein in diet (2007)	12.9	FAO
GDP (PPP) per capita in international dollars (2010)	2,577	Asian Development Bank

FAO = Food and Agriculture Organization of the United Nations, GDP = gross domestic product, kg = kilogram, km = kilometer, PPP = purchasing power parity, t = ton.

Source: National Statistical Office of Papua New Guinea. National Census 2000. Port Moresby.

## Demography

The population, distribution, and population density statistics for PNG's maritime provinces presented in this section are based on the most recent (year 2000) census. However, data available from the 2000 census are already outdated. The data presented in Table 2 more accurately depict the geographic distribution of the population rather than its absolute size. Most of PNG's provinces are located along the coast, except for the seven highland provinces. Most of the population in the marine provinces derives the bulk of its food supply and livelihood from marine resources. These marine provinces include Central, East New Britain, East Sepik, Gulf, Madang, Manus, Milne Bay, Morobe, the National Capital District, New Ireland, Oro, West New Britain, West Sepik, Western province, and the Autonomous Region of Bougainville.

## Traditional Knowledge Management

Papua New Guineans have survived harmoniously with the environment through a set of survival-based practices. Traditional knowledge regarding terrestrial and marine resources has evolved in response to changing weather patterns; population parameters; land acquisition; and advancement of traditional agriculture, hunting, and harvesting technology, with the primary goal of ensuring a reliable food supply and, hence, survival of the clan.

**Table 2 Land Area and Population of Papua New Guinea's Maritime Provinces**

Province	Land Area (km <sup>2</sup> )	Population	Population Growth Rate (%)	Population per km <sup>2</sup>
Central	29,900	167,000	2.0	225
East New Britain	15,100	247,000	4.2	220
East Sepik	43,700	270,000	1.6	175
Gulf	13,500	64,000	0.6	36
Madang	28,000	251,000	1.6	110
Manus	2,000	37,000	3.0	500
Milne Bay	14,100	194,000	2.4	>300
Morobe	33,525	307,000	1.5	400
New Ireland	9,600	133,000	4.0	162
Oro	43,700	110,000	2.5	36
West New Britain	20,800	99,000	3.3	220
West Sepik	36,000	151,000	1.8	98
Western	97,000	106,000	2.2	26
Autonomous Region of Bougainville	9,300	157,000	2.4	300

km<sup>2</sup> = square kilometer.

Source: National Statistical Office of Papua New Guinea. National Census 2000. Port Moresby.

Such traditional knowledge, which is passed orally from each generation to the next, addresses a wide range of social imperatives, such as the division of authority, social protocols, survival skills, the timing of hunting and harvesting seasons, demarcation of gender roles, clan ownership rights, provision of security, and celebration of feasts. Similarly, history is passed from each generation to the next orally through legends and myths recounted through song, dance, and initiations.

PNG's body of traditional knowledge is both extensive and complex, partly because of the country's diversity, and partly because of the changing livelihood status of numerous social groups. Such knowledge includes the appropriate manner in which to respond to changes in the physical environment in the immediate area of the social group concerned. Traditional knowledge concerning local ecological parameters is complex, representing decades of societal and institutional learning regarding species, the immediate physical environment, and the interactions between them (Drew 2005).

Traditional knowledge pertaining to marine conservation and resource management abounds in PNG's coastal communities, particularly with regard to

- (i) authority that permits or forbids harvesting,
- (ii) identification of the individuals who are permitted to harvest (e.g., specific clan members, females, newly initiated men),
- (iii) methods of harvesting marine animals (permitted types of fishing gear),
- (iv) ownership of particular sections or zones of the sea surface, and
- (v) timing and duration of closed and open seasons.

However, in coastal communities, many traditions are eroding as a result of loss of traditional authority and values, population increase, and introduction of a money economy. Erosion of these traditions tends to occur at different rates.

The following are several reasons why traditional knowledge is relevant to addressing present-day degradation of the environment and natural resource base:

- (i) This knowledge is a source of current and historical information regarding marine biology and ecology.
- (ii) It provides a baseline for understanding the status of the resource base in historical context, which aids in formulating appropriate conservation measures.
- (iii) It provides a basis for protecting marine areas that have historically provided food and income to communities in a sustainable manner.
- (iv) Organizations, such as the PNG Centre for Locally Managed Areas, can use this knowledge to assist local communities in managing the areas from which they extract resources, and do so in a culturally appropriate way.
- (v) It provides a basis for formulating marine law at all levels of government. This encourages local communities to actively conserve and manage the marine environment on which their livelihood depends.

Erosion of long-standing customs and traditional systems of authority inevitably results in the proliferation of unsustainable harvesting practices. This is particularly important in the PNG context, since subsistence farmers and fishers comprise the bulk of the population. In many coastal communities, few alternative livelihood strategies are available to local residents. When

people harvest marine resources outside the confines of traditional knowledge and practices, rapid depletion of marine stocks often results.

Other negative impacts occur when traditional knowledge and authority erodes: (i) loss of baseline information for conservation and research; and (ii) conflict between community elders who hold positions that have traditionally provided them with heightened social status, but who lack scientific knowledge on one hand, and younger people who have acquired some scientific knowledge through formal education on the other.

Since traditional knowledge and harvesting practices are passed orally from one generation to the next, little written documentation concerning it exists. Most of it is thus at great risk of being lost. Because of the value of such knowledge in formulating future conservation efforts, its documentation, archiving, and storage by institutions such as the national library is of great value. Currently, the most comprehensive review of such knowledge as it pertains to the marine resource is the *Aquatic Knowledge and Fishing Practices in Melanesia*.<sup>1</sup>

The Convention on Biological Biodiversity encourages countries with significant marine resources to acknowledge the value of traditional knowledge, particularly with respect to assisting local communities in managing biodiversity within their respective areas. In PNG, customary rights for managing local areas are vested in communal clans or families. To be effective, any governance structure relating to the marine resources must acknowledge and reflect these rights.

As noted earlier, an efficient way of accomplishing this is for government to integrate into its overall planning traditional knowledge regarding marine resource conservation as practiced by local coastal communities. Since legal and policy gaps exist in government policies and legislation that address natural resource issues in coastal communities, such integration could occur within the framework of existing legislation, as has been done with the Biialla Local Level Government law on conservation of marine environments.

The following are guidelines for managing traditional knowledge regarding the marine environment:

- (i) A single organization should manage all information regarding traditional resource conservation practices. In the PNG context, the Learning and Training Network (LTN) under the Coral Triangle Initiative could function as a knowledge management hub. Under this arrangement, the LTN would be responsible for managing this database and sharing it with organizations that facilitate marine research and conservation in PNG.
- (ii) Regardless of whether its origin is PNG or another jurisdiction, all information generated should be copied to the hub (LTN). The hub would be responsible for storing this documentation; and creating a database of all such documentation in collaboration with the national library and archives, and any other relevant organizations.
- (iii) All information regarding traditional knowledge concerning resource conservation practices should be used in a way that is endorsed by the custodians of this information (Hamilton and Potuku 2007). Under such an arrangement, the custodians of the traditional information are its owners, rather than the designated information hub.

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<sup>1</sup> N. Quinn, ed. 2001. *Aquatic Knowledge and Fishing Practices in Melanesia*. Port Moresby: Uramina Nelson. p. 140.

## Gender Issues

Men and women in Pacific island countries including PNG relate to the environment in a manner specific to their gender roles within their particular communities. These roles include those relating to reproduction, family care, production, and decision making. Studies of Pacific island communities have shown that resource mapping reveals what men and women value in the environment around them (see in particular the results for Fiji obtained by Seniloli et al. 2002).

Studies performed in PNG find that in some areas, female fishers account for 20%–50% of the annual catch (Kinch 2003). However, with the introduction of a money economy, women's position tends to be usurped as a result of changing values and breakdown of traditional social structures. Although specific gender roles exist with respect to the division of labor, MacIntyre (1983) found such roles more sharply delineated with respect to ideology than practice. As with men, women are also exploiters of the marine resources.

While women play an active role in harvesting, processing, and marketing goods obtained from the marine resources, they are poorly represented at the management level and in related planning processes. Since women contribute significantly to the harvesting of marine products, such programs should require their participation as equal partners with men.

Because of depleted inshore marine resources due to habitat loss and overharvesting, fisheries agencies in Pacific island countries are encouraging expansion of offshore fishing by coastal residents, for example, by providing gear and training (Kinch 2003). Unfortunately, women receive few or none of the benefits of such programs. In part for this reason, many donor- and government-funded programs emphasize "increased participation by women, both as beneficiaries and agents in the development process, and improvement in the quality of life" (Kinch 2003).

Interestingly, the expenditure patterns of men and women differ significantly. Women are more likely than men to spend their income on children, whereas men tend to spend their income on tobacco and alcohol, often contributing to health and social problems. Similarly, in PNG, it is common for women to eat after men, and to eat less.

Women becoming wage earners are not always an ideal outcome, as they are often expected to also fulfill their traditional gender roles in the homes and in their communities. Nevertheless, managing the natural resource base in an optimal manner requires women to have the same level of access to training, education, and jobs as men. Ultimately, such an outcome improves the health and well-being of the family and the community as a whole.

In PNG, men are viewed as the leaders. They continue to dominate decision making within the family, local community, and society. Natural resource management has been a duty performed by men, as they traditionally have had more power than women. For example, in the Talasea area of West New Britain Province, men make decisions regarding marine resources within the locally managed marine area (Helen Rei, PNG Centre for Locally Managed Areas, personal communication). Women have little to say, even as participants in training programs and workshops, particularly as this relates to the sharing of views and ideas. However, with education, exposure to information, and advancement of the legal rights of women (as promulgated by

the Convention on the Elimination of All Forms of Discrimination against Women) and the influence of churches, men's dominance over women is slowly waning. Equal opportunity and shared responsibilities in the home, community, and society overall are emerging, albeit at a slow pace.

PNG has both matrilineal and patrilineal ownership systems, and matrilineal and patrilineal systems of access to, and use of natural resources. Overall, women have traditionally held relatively high status in PNG societies. They tend to be central to land ownership and food production. In the Autonomous Region of Bougainville, East New Britain, Milne Bay, and New Ireland, women own the land, sea, and natural resources. In other provinces, such ownership systems are patrilineal.

Although changes in roles and responsibilities tend to bring about positive results for both men and women, the opposite is true in the use of natural resources and division of the benefits derived from such use. For example, in Lihir, women own all natural resources, but men in the *Hausboi* (sacred meeting place for men only) generally make decisions regarding the use of such resources. In matrilineal Milne Bay Province, the men—brothers in particular—have greater access to the benefits of resource extraction than do women or children. Women are generally not consulted in decisions regarding the division of such benefits, a folkway that occasionally results in familial conflict.

In natural resource management and marine conservation, men tend to make decisions regarding the use of natural resources, and have greater access to the benefits from resource extractive activities than do women and children. This is even true in PNG's matrilineal societies. Government bodies, donor agencies, nongovernment organizations, and civil society organizations are advised to consider gender differences when formulating plans for engaging such communities.

The relationship between PNG men and women has slowly changed with the advancement of modern values, education, and legal rights. In some spheres of PNG society, women are now equal partners with men with regard to leadership responsibilities, a dramatic change in the role of women since the country's independence. Women now take professional jobs in government, tertiary institutions, and the private sector, in addition to managing households. In this regard, the overriding aim of policy toward women in PNG has been increased participation as beneficiaries and agents in the development process, and in improvement in the overall quality of life.

## Payment for Ecosystem Services

All ecosystems provide various services, which can be disaggregated into several types: (i) provisioning (e.g., fisheries), (ii) regulating (e.g., weather regulation), (iii) supporting (e.g., soil formation), and (iv) cultural (e.g., tourism). Until recently, most of the services provided by ecosystems were assumed so abundant that nothing was foregone in their use. However, once ecosystems began to be degraded through exploitation, it became apparent that the rate at which ecosystems can provide such services is finite, underscoring the fact that as with virtually all other goods, ecosystem services have scarcity value.

In the case of handmade goods, markets that price this scarcity value in monetary terms naturally develop. However, for a number of reasons, such markets do not develop in the case of ecosystems. Thus, a system of payment for ecosystem services (PES) is necessary to ensure that ecosystems can continue to provide that finite stream of services. In short, while the services provided by ecosystems have economic value, people only respond to that value when they are made to pay for it. PES arrangements are necessary to ensure that the services provided by ecosystems are used sparingly enough to ensure their sustainability, since in the absence of such payment, lavish use, overexploitation, and degradation of the ecosystem inevitably result.

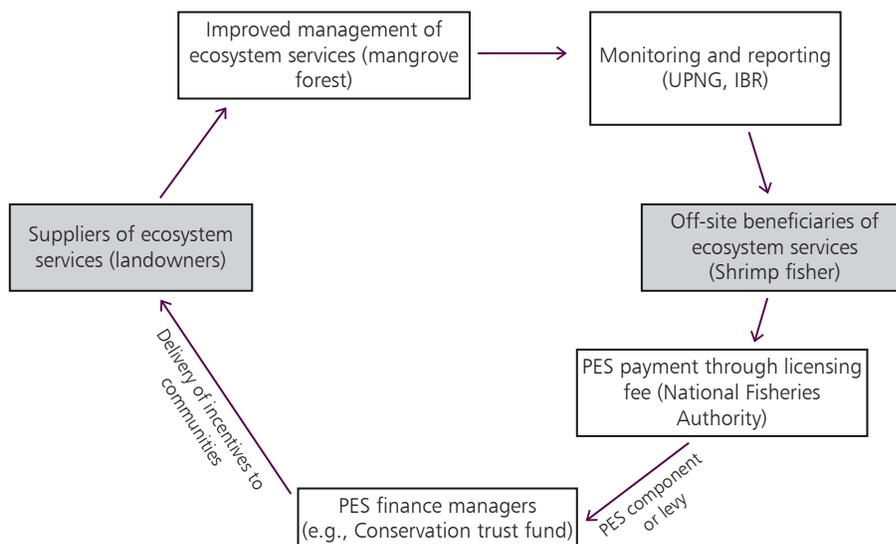
No formal PES schemes exist in PNG. However, in the recreational diving industry, a small-scale informal PES system has developed: divers pay a fee to local communities for the privilege of diving on their reefs and shipwrecks. The fees collected typically finance community activities such as youth sports, church renovations, and school feasts. Such a system provides an incentive for the community to safeguard the reef ecosystem. Measures for protecting the health of the reef primarily include landowners banning reef-damaging behavior such as anchoring on the reef or fishing with dynamite or poison rope. Community members monitor and enforce community rules that ensure sustainable use of the reef ecosystem, while village elders and councilors dispense punishment for noncompliance with community rules.

The National Fisheries Authority (NFA) has valued the shrimp industry in PNG at approximately \$14 million annually (Lokani, personal communication, 2012), making the industry an ideal candidate for a PES scheme. Even though shrimps are harvested offshore, the organic material on which these shrimps feed originates in inshore areas, particularly mangrove swamps, which also act as shrimp nursery areas. Mangroves provide a valuable service to the life cycle of shrimps, a service that until recently has always been considered “free,” in that nothing seemed to be foregone in the provision of this service. However, this apparently “free” service provided by mangrove forests is an illusion. Research by Shearman (2010) used satellite imagery to quantify the net loss in mangrove area in the northern Gulf of Papua over 1973–2002 that resulted from mangrove management practices then. In net terms, this area declined by 992 hectares (ha) over the study period.

In addition to benefiting the shrimp industry, mangrove forests protect the shoreline, and provide building materials and food to the communities that own them. Nevertheless, during the study period, these communities appear to have not engaged in any rehabilitation or conservation efforts. If the ecosystem’s current pace of degradation continues, the shrimp output will inevitably decline. It is in the shrimp industry’s best interests to ensure that mangroves continue to populate the coast at optimal levels.

A PES scheme for the shrimp industry would incentivize ecosystem owners to modify their use of mangroves and allocate resources to their management and conservation. [Figure 1](#) depicts a model PES scheme for PNG’s shrimp industry. Under this PES scheme ([Figure 1](#)), shrimp fishers who benefit from mangrove forest services would each pay an additional levy together with the annual licensing fees paid to NFA. This additional levy would constitute the industry’s contribution to the financing of improved management of the mangrove ecosystem. The NFA would pass the revenues from the collected levy to the PES finance manager for disbursement. After identifying the community development requirements of participating landowning communities, the PES finance manager would formulate a disbursement mechanism for the funds collected in consultation with the landowning communities. The financing provided to

**Figure 1 Model Payment for Ecosystem Services Scheme for the Papua New Guinea Shrimp Industry**



IBR = Institute of Biological Research, PES = payment for ecosystem services, UPNG = University of Papua New Guinea.

Source: Author.

the community would incentivize community members to maintain or even expand the stream of services provided by the mangrove ecosystem they own.

Payments of mining and logging royalties were previously made to landowners in cash, rather than being channeled into income-generating activities or community infrastructure. As a result, mining and logging companies and recipients of royalties saw these as one-time payments for the environmental destruction caused by logging or mining. To ensure that such royalty payments result in environmental improvement rather than degradation, PES schemes should never be presented to landowners as compensation payments for environmental destruction. Instead, they should be presented as opportunities for ensuring that the services provided by the ecosystem to the local community are managed in a way that ensures a sustainable stream of such services over the long term.

The most comprehensive national PES system proposed to date is Reducing Emissions from Deforestation and Forest Degradation mechanism. Formulated by PNG experts in 2009 and tailored to the PNG context, the disbursement and benefit-sharing arrangements under this system had the following characteristics:

- (i) Only a minor portion of the benefits paid to landowners is paid in cash.
- (ii) Monetary benefits paid in cash are remitted bi-annually directly into family accounts. These cash payments are disaggregated into cash payments deposited into household

- accounts, and payments deposited into segregated accounts to be used for school fees and hospital treatment.
- (iii) Nonmonetary benefits are channeled into developing community infrastructure in a manner consistent with the community, ward, local government, or district development plans.
  - (iv) A portion of the income generated by the PES scheme is channeled into income-generating activities to ensure that payments for ecosystem services are not viewed as a single source of income from the ecosystem concerned. Income-earning activities must be compatible with the community's sustainable land use plan, which forms the basis of the community's commitment to the PES scheme and the PES financing contract.
  - (v) A minimum of 70% of the income generated from PES scheme payments must go to the landowners concerned.

The purpose of disbursing 70% of the funds generated by the scheme to landowners is that of providing a monetary incentive for landowners to rehabilitate and conserve the ecosystem. An important PES contract condition is that monitoring and reporting are performed in the community by local environmental rangers, together with national staff from the appropriate regulatory agencies.

## Capture Fisheries

### Commercial Fisheries

PNG's tuna and shrimp industries make up the country's major commercial fisheries. The tuna fishery comprises the purse seine subsector, longline subsector, and handline subsector; and while small in output, it employs a significant number of fishers. Longline and handline fishing activities are for PNG citizens only. All vessels operating in these subsectors fish exclusively in PNG national waters.

Domestic and foreign vessels operate in purse seine subsector. Domestic vessels comprise PNG-flagged and PNG-chartered vessels, which support onshore processing facilities in PNG. PNG-flagged vessels fish primarily in PNG waters, but occasionally on the adjacent high seas. PNG-chartered vessels fish in PNG waters and waters outside PNG jurisdiction. Under access arrangements received in exchange for payment of fees, foreign vessels are authorized to fish within PNG's exclusive economic zone (EEZ), but not in PNG territorial or archipelagic waters.

The total tuna catch in 2010 in PNG waters was 702,969 tons. Of this, foreign vessels operating under access arrangements accounted for 78.7%. PNG-chartered vessels (locally based foreign vessels) accounted for an additional 16.7%, and PNG-flagged vessels accounted for the remaining 4.1%. The total output of the longline subsector in 2010 was 3,120 tons, or 0.5% of PNG's total tuna catch.

Due to closure of neighboring high-sea pockets, nearly all of the fish caught by PNG-flagged vessels during 2010 were harvested from PNG waters. The 63,397-ton catch of PNG-chartered vessels harvested outside PNG waters was mainly taken from the waters of other parties to the Nauru Agreement.

In 2010, 256 vessels were active in PNG waters. Of these, 32 were longline and handline vessels, and 224 were purse seine vessels. Of these 224 vessels, 9 were PNG-flagged, 39 were PNG-chartered, and 176 were foreign vessels operating under fee-for-access arrangements. In 2010, the total foreign-vessel purse seine fishing effort was 15,796 days of fishing and searching inside national waters. The total longline fishing effort was 62,605 hundred hooks. Catches by purse seine vessels in PNG were mainly from free schools, which accounted for about 72% of the total catch. The remaining 28.4% of the total catch employed fish attracting devices, of which drifting devices made up 11.9%, anchored devices 8.2%, logs 7.8%, and mammals 0.5%. About 82% of the free-school catch was harvested by foreign vessels. The remaining 18% was caught by PNG-flagged and PNG-chartered vessels.

Gillett (2009) noted that PNG's shrimp catch has declined since 2004, when it equaled about 600 tons with a value of \$4 million. However, a recent estimate by the NFA places the annual value of PNG's shrimp catch at approximately \$10.5 million (P. Lokani, personal communication, 2012).

Little information is available concerning the annual volume or value of the bycatch. However, the total annual average market value of PNG's fisheries bycatch is estimated at K350 million–K400 million (\$170 million–\$184 million).<sup>2</sup> Unfortunately, this lack of information on annual bycatch could lead to overexploitation of vulnerable species. Given that capacity constraints currently prevent rigorous monitoring and inspection of foreign vessels operating within PNG's EEZ, this important information is unlikely to become available in the future, unless a more innovative means of collecting such information can be devised.

Another fisheries subsector that impacts the environment is processing and canning. Under the government's policy of promoting added-value exports, the fish-processing subsector has grown over the past few years, and appears set to continue this trend with another new processing plant to be constructed at Wewak. As with other types of food processing, the processing of fish produces a concentrated organic effluent that is usually a loose slurry comprising water, fish tissue, and fluids; macerated body parts such as fish heads, bones, fins, and scales; and soft tissues such as gut and liver. This mixture is usually skimmed and screened to remove larger floating and suspended solids before being discharged through a marine outfall. The potential impacts associated with this discharge depend on the location of the discharge, and the rate of dispersion and dilution at the point of discharge. This effluent has high biological oxygen demand, primarily from the dissolved organic fraction; and contains a high concentration of particulate matter likely to have near-neutral buoyancy.

Ultimately, PNG's commercial fishing industry lacks accurate data regarding fish numbers, species diversity, catch rates of both target and non-target species, and the range of factors and environmental conditions affecting fish population recruitment and population growth rates. In the absence of such information, it is difficult to accurately estimate the sustainable harvest yield (i.e., sustainable catch) for any particular species. Without such information, protecting PNG's fish populations from overexploitation through formulation of fish stock management plans requires a cautious approach.

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<sup>2</sup> Based on exchange rate prevailing in December 2012.

## Subsistence and Artisanal Fisheries

PNG's commercial fishery is the major fisheries subsector in terms of the weight of the total catch. However, subsistence and artisanal fisheries are important subsectors with regard to socioeconomic variables. Fish is a major source of animal-based protein and part of the staple diet of PNG coastal populations, both on the mainland and throughout the country's islands.

Fish is also a major source of cash income for coastal villagers, many of whom haul their catch 100 kilometers or more to a market where it can be sold for cash. In many communities, fish not taken to market or consumed immediately are preserved through smoking, as fresh fishes degrade rapidly in PNG's tropical climate. The subsistence and artisanal sectors provide most of the fish for the domestic market, as well as for export. This includes export niche markets such as shellfish and *bêche-de-mer*. The *bêche-de-mer* fishery is reported to be the most valuable coastal fishery in PNG (Australian Marine Science and Technology 1997; reported in Mitchell et al. 2001). Detailed surveys of coastal fisheries in four representative sites in PNG's outer islands were made in 2006 (Friedman et al. 2008), providing typical socioeconomic data as well as assessments of local stocks and management suggestions.

PNG's subsistence and artisanal fisheries operate mainly in coastal and nearshore waters. The particular harvesting method used depends on the target species. Although these fisheries have supported PNG's coastal populations for centuries, in recent years, rapid growth of the country's coastal populations and increasing demand for cash income have significantly expanded subsistence and artisanal fishing activities. These have raised serious concerns over the sustainability of coastal fish stocks.

This is particularly true of species with high export value such as *bêche-de-mer* and some shellfish such as trochus and giant clams. Because the price of these species on export markets is relatively high, these species are particularly at risk of being overharvested, given PNG's cash-poor economy (Mitchell et al. 2001). For example, rural island households in Milne Bay Province have responded to their loss of purchasing power due to inflation, decreasing prices of commodities such as copra, and increasing demand for sedentary fish products by increasing the rates at which they harvest commercially valuable species.

Reconstruction of PNG domestic marine fisheries during 1950–2010 using a variety of sources indicated average catches of 22,000 tons/year over the period and about 44,000 tons/year in the late 2000s. Over the 60 years covered, PNG's non-tuna catches were four times those reported in official statistics. Of the total, 66% was subsistence and 29% artisanal, equivalent to small-scale commercial fishing. The reconstructed catches are similar to the estimates of Gillett (2009). For 2007, a subsistence harvest of 30,000 tons and 7,500 tons for inshore commercial subsector—close to values in the reconstruction for 2005–2010 of 30,450 tons and 7,100 tons, respectively, for these subsectors.

The reconstructed catches showed a spike that reached 95,000 tons/year in 1992, when exports of *bêche-de-mer* reached a peak; these subsequently declined until a moratorium on *bêche-de-mer* exports was declared in 2009 (Teh et al. 2014).

Anecdotal evidence increasingly suggests that other coastal stocks are also declining. However, reliable information regarding coastal fish stocks and catches is lacking. As a result, accurate

estimates of sustainable yield are not possible; nor is it possible to determine whether current catch rates would constitute overexploitation. Given this, a cautious approach to calculating sustainable catch rates should be adopted. That said, subsistence and artisanal fisheries are, by nature, difficult to manage and regulate. Experience to date suggests that sustainable management of these fisheries is best achieved through a combination of agency regulation, community-based awareness programs, and local skills development programs in fishing communities. Such programs should be designed to engage and then empower the communities in a manner that allows them to monitor and manage their own local fisheries in a sustainable manner.

There is considerable concern at both the local and national levels over destructive fishing methods that have been introduced, including dynamite fishing and poisoning with derris powder. These methods are nonselective in impact and destroy large numbers of organisms of all species. In the case of dynamite fishing, it physically destroys the habitat as well.

## Aquaculture

Tilapia is the most widely cultured species in PNG. The country's remote highlands and northern coastal provinces are home to an estimated 10,000–20,000 household-scale freshwater tilapia farms (SPC Aquaculture Portal 2010). Marine aquaculture is not widely practiced in PNG; however, the success of some small-scale pilot and commercial marine aquaculture projects suggests that the future development potential of marine aquaculture is significant.

A small-scale marine aquaculture venture in Madang, Bismarck Barramundi, is an example of such successful implementation. This project was included in a proposed investment portfolio under the Nucleus Agro-Enterprise Project of the Asian Development Bank, the implementation of which is now complete. Another such venture that is currently operating was initiated in Daru by the PNG Sustainable Development Project, which breeds and rears barramundi to the fingerling stage at which they are large enough to be introduced into the wild. Given that they reach profitability, marine aquaculture ventures could generate significant amounts of revenue, contribute to food security, and relieve pressure on natural fish stocks. Other marine aquaculture ventures active in PNG include pearl and seaweed farming in Milne Bay Province, and shrimp farming in East New Britain.

## Tourism

Tourism is one of the fastest growing industries worldwide. In the South Pacific, tourism revenues reached \$1.52 billion in 2004.

PNG's Medium Term Development Strategy 2005–2010 estimated the foreign exchange earning potential of tourism and its potential for creating jobs. As a result, the government tripled its tourism budget allocation to \$2.1 million in 2004 and, in 2006, provided the Tourism Promotion Authority with nearly \$4.6 million.

However, PNG's tourism industry remains fragmented, despite the support of industry bodies, representative associations, and government through the Tourism Promotion Authority. A government-sponsored commission is assessing the effectiveness of the current approach to developing a sustainable tourism sector. Tourism in PNG has traditionally been developed through private sector initiatives with minimal government support. Key industry participants include the airlines; hotel and hospitality subsector; tour operators; and niche industries that provide tourist services in diving, kayaking, surfing, trekking, and historical and cultural activities.

In 2005, PNG received nearly 70,000 overseas visitors, of whom 26% were tourists, the remainder being business travelers. In all, these visitors generated an estimated \$175 million in revenue.

The potential revenue-generating potential of nature- and culture-based tourism in PNG is significant. The only developed tourism sector is diving, which accounts for approximately 68% of all tourist arrivals (Tourism Promotion Authority, 2001 visitor survey). However, if properly managed, many other tourism-related activities could generate considerable foreign exchange earnings. These include outdoor activities such as canoeing, climbing, marine-based recreational activities, rafting, and trekking, as well as bird watching, cultural tours, and village-based tourism. However, under the current ad hoc approach to tourism development, a substantial increase in tourist arrivals is likely to adversely impact the environment.

## Minerals, Oil, and Gas

PNG has extensive mineral resources such as cobalt, copper, gold and silver, natural gas, nickel, and petroleum. Over the past 30 years, extraction of these resources has generated significant amounts of foreign exchange, infrastructure development and training, and substantial number of new workplaces. Mining and petroleum accounted for approximately 75% (\$385 million) of PNG's total merchandise exports (\$500 million) in the third quarter of 2002 (Bank of Papua New Guinea 2002). In that quarter, mineral export receipts (excluding crude oil receipts) accounted for 49% of total merchandise exports, while receipts from crude oil exports accounted for 26%.

All stages of the mining cycle from exploration to construction, operation, closure, and post-closure activities generate environmental impacts, though the magnitude of these impacts depends on the extraction methods employed and the scale of the mining activity concerned. The residual environmental impacts of mining can occur long after mine closure.

In 2005, Nautilus Minerals publicly declared its intention to pursue seabed mining in PNG. Nautilus Minerals Niugini (a wholly owned subsidiary of Nautilus Minerals) holds exploration title over a particular deposit, and has been exploring this site since 2005. Nautilus Minerals is the first company to commercially explore the ocean floor for gold, copper, and sulfide deposits.

## Transport and Shipping

PNG has 17 commercial ports, most of which are quite small. It has innumerable small wharves, jetties, and other beach landings but the majority is in poor condition and carries little traffic. The ports serving Lae, Kimbe, Madang, Port Moresby, and Rabaul carry international and coastal traffic; and the infrastructure at these ports is adequate for the freight traffic they handle. However, the infrastructure at lesser ports, such as Alotau, Kavieng, Oro Bay, and Wewak, is sufficient solely for providing basic services to coastal traffic. Such services are limited to loading and offloading over the ship's side to and from small village boats and canoes. Many of these smaller ports are unusable in poor weather.

Kimbe, which handles agricultural export traffic; and Madang, which serves many small coastal vessels, are the most frequently visited ports. Lae, Port Moresby, and Rabaul handle the greatest amount of cargo, as most imports pass through Lae and Port Moresby. Lae is the major import and export point for the populous highlands region, goods being moved to and from this port by road. In recent years, the annual throughput at PNG's major ports has grown at approximately the same rate as the national population. Import and export tonnages (which are increasingly containerized, but also include growing logging shipments) account for approximately one-third of total tonnage, and majority of the growth achieved. Passenger cruise visits have also increased, albeit from a small base. Coastal passenger operations are significant between the 20 larger centers that include Buka, Kavieng, Kimbe, Lae, and Madang. However, recent declines in traffic have to some extent reduced the services provided. Community-based services—often provided by small, open, overloaded craft operating over stretches of the open sea and lacking safety facilities and navigational aids—also extend to many smaller coastal villages.

The 1980 Merchant Shipping Act and the 1976 PNG Harbours Board Act provide the legal framework for managing the maritime sector. The National Maritime Safety Authority is responsible for all maritime safety matters; and it installs and maintains navigational aids, coordinates search-and-rescue services, prevents and responds to oil spills and environmental disasters, handles registration and licensing of vessels greater than 10 meters in length, ensures small-boat safety, conducts hydrographic surveys, and ensures that PNG's maritime safety obligations under international conventions are met.

# Threats and Vulnerabilities

## Current Issues in Marine Resource Management

### Degradation of Fisheries and Food Security

Fish is a major source of animal dietary protein in Papua New Guinea (PNG). Annual per capita fish consumption is 13 kilograms (kg), but reaches 53.3 kg (Bell et al. 2009) in coastal communities. Subsistence fishing accounts for approximately 64% of total fish consumption in rural areas. However, access to fish is poor for residents living more than 5 kilometers (km) inland. This is reflected in their estimated annual per capita fish consumption, which is less than 5 kg.

Significant loss of coastal fisheries is evident along PNG's coastline. Marine resources in provinces that have depended heavily on them to sustain livelihoods have come under increasing stress because of fish catches that exceed sustainable levels, destructive fishing methods, and use of outboard engine-powered crafts to access distant or protected fishing grounds. Agroforestry projects are active in many of the 14 maritime provinces. Over the past 20 years, many of these projects have contributed to marine resource degradation. Siltation from seasonal heavy rainfall has likewise contributed to degrading marine resources, particularly when it follows extended droughts.

Even coastal provinces with major gold and copper mines have suffered from food insecurity. In the Western Province, which borders Indonesia, flooding in May–June 2012 caused by heavy rain along the Fly River inundated 15 coastal villages, destroying food gardens, smothering seagrass meadows, and causing tributaries of the Fly River to flood. Following this, health concerns were widespread, and most marine-based food was deemed unsafe to eat for several months.

### Threatened Species

Many of PNG's marine species are currently under serious stress, mainly because of unsustainable fishing practices and fishery management regimes that endanger particular species, such as freshwater dolphins, dugong, and three species each of marine turtles and freshwater turtles.

The major factors causing the decline of these species include (i) unfavorable weather patterns, (ii) runoff from heavy rainfall, (iii) habitat degradation and loss of foraging and breeding areas because of illegal fishing practices, (iv) illegal unreported and unregulated fishing, and (v) lack of research regarding these threatened species and insufficient monitoring of their capture

rates. PNG's relatively porous international boundaries with Australia and Indonesia have also facilitated unsustainable rates of capture of these species.

Mangrove forests are likewise in retreat due to unsustainable rates of exploitation, particularly in the Gulf of Papua. While not a threatened species, mangroves are a significant source of food and livelihood for the communities surrounding them. As mentioned, the government is considering instituting a payment for ecosystem services scheme that would provide revenue and incentives for local residents to maintain mangroves.

### Seabed Mining

The Solwara 1 Massive Sulfide prospect belonging to Nautilus Minerals is located in PNG's Bismarck Sea, an area containing significant deposits of metal sulfides, gold, and silver. While Nautilus Minerals has been granted official permission to begin mining the seabed, the Solwara 1 project has been put on hold because of public dissatisfaction with some of the initiative's environmental aspects.

Three major environmental problems are expected to result from mining nodule deposits on the seabed:

- (i) The collector unit will destroy several centimeters of the seabed's topmost portion, disrupting its flora and fauna. In addition, the collector unit's propulsion system will stir up seabed sediment, thereby burying organisms that live in and around the tracks of the collector unit.
- (ii) Particulate matter and trace metals discharged with the wastewater during surface treatment will make the surrounding waters more turbid.
- (iii) Onshore processing of the nodule deposits will produce wastewater, tailings, and slag in the same manner as all land-based mining operations.

# National Plan of Action Initiatives and Future Plans

The Papua New Guinea (PNG) National Plan of Action (NPOA) for marine resources identifies five goals:

- Goal 1: Designation and effective management of priority seascapes
- Goal 2: Application of an ecosystem approach to management of fisheries and other marine resources
- Goal 3: Establishment and effective management of marine protected areas
- Goal 4: Application of climate change adaptation measures
- Goal 5: Improvement of the status of threatened species

All aspects of the NPOA are consistent with the Coral Triangle Initiative (CTI) principles and guidelines. Each of these five goals includes appropriate strategies and quantitative targets.

For example, the priority seascapes identified under Goal 1 comprise large-scale geographies that have been prioritized for investment and action. Under these investments and actions, best practices are to be applied and their use expanded. Similarly, Goal 2 specifies that the ecosystem approach to fisheries and marine resource management is to be fully applied under the NPOA. The effective management of marine protected areas (MPAs) under Goal 3 is to include community-based resource utilization and management.

This section describes PNG's progress in achieving these goals.

## Goal 1: Designation and Effective Management of Priority Seascapes

Seascapes are defined as adjacent coastal, nearshore, and offshore areas with discrete ecological characteristics. They are equivalent to ecoregions.

Goal 1, which addresses PNG's seascapes, comprises two major targets: (i) designate PNG's priority seascapes, completing investment plans relating to them, and specifying the timing of the investment initiatives; and (ii) achieve sustainable management of all marine and coastal resources within all of PNG's priority seascapes.

Large-scale marine areas are the geographical focus of major investment and development activities in PNG. Priority seascape investment plans have been completed, along with arrangements for sequencing investments in a manner consistent with PNG's Vision 2050.

Progress on seascape management has been limited to circulation of a discussion paper on MPAs. However, plans call for developing a separate marine policy for these areas.

Nongovernment organizations (NGOs) such as Conservation International, The Nature Conservancy, the Wildlife Conservation Society, and the Worldwide Fund for Nature (WWF, formerly the World Wildlife Fund), contribute to PNG's priority seascape conservation initiatives, which relate to MPAs and locally managed marine areas.

The Bismarck Solomon Seas Ecoregion Initiative encompasses both the Admiralty and Bismarck archipelagoes, and the northern coast of the PNG mainland. Some of the few tropical marine ecosystems in these portions of PNG remain relatively unaffected by human activity.

This section summarizes the progress thus far in achieving the first target of this goal: Achievement of legislative, policy, and regulatory frameworks for applying the EAFM.

## Goal 2: Application of an Ecosystem Approach to Management of Fisheries and Other Marine Resources

PNG does not yet have specific policy and legislation relating to the ecosystem approach to fisheries management (EAFM). However, the government has formulated draft policies relating to fish aggregation devices, community-based resource management, and protected areas that complement and support the EAFM. The government, NGOs, and other stakeholders currently implement elements of the EAFM. However, the impact of these initiatives falls short of results had a transparent EAFM policy already been in place, as well as management plans that focus on the ecosystem in general and exploited fish and marine organisms in particular.

This section summarizes the progress thus far in achieving the first target of this goal: achievement of legislative, policy, and regulatory frameworks for applying EAFM.

To date, no specific legal framework or set of laws addresses the implementation of EAFM principles. However, existing national and local legislations could be adequate for this purpose. For example, Section 28, Subsection 2, of the Fisheries Management Act, 1998 could be modified as follows:

"The Managing Director may, and where the Minister so requires, shall cause to be drawn up a[n] Ecosystem and Fishery Management Plan in respect of any fishery resource in the fisheries waters."

Similarly, a new sub subsection (3) under Section 28 could be inserted with wording as follows:

"identify and describe the status of the ecosystem and its characteristics, including the use of the ecosystem by other users."

The Nature Conservancy in Kimbe and Manus has trained 200 community practitioners and fisheries officers on EAFM principles. An EAFM sub-working group now reports to the PNG Marine Program Technical Working Group, which in turn reports to the CTI National Coordinating Committee.

The following key gaps in implementing the EAFM have been identified:

- (i) lack of an EAFM policy formally endorsed by the National Fisheries Authority Board;
- (ii) lack of EAFM provisions in current national or local legislation, which could be addressed by inserting EAFM-specific provisions in the Fisheries Management Act, and by formally incorporating EAFM provisions into local government environment, conservation, and fisheries laws;
- (iii) existing fisheries management plans not allowing management of both fisheries and ecosystems, where such expanded management plans to be named fisheries and ecosystem management plans; and
- (iv) lack of knowledge and experience in applying EAFM principles on the part of fisheries officers, NGO technical officers, and community field practitioners, resulting to EAFM awareness training and implementation of EAFM principles not as effective as they would otherwise be—this lack must be addressed through training on EAFM.

In light of the above, the Department of Environment and Conservation (DEC) is improving its organizational capacity for integrated coastal resource management and EAFM with support from the Asian Development Bank (ADB). Following a review of existing policy, the DEC will formulate a work program on policy development to address the gaps. The DEC is encouraging PNG-based environmental law groups to participate in EAFM-related policy making. The DEC has targeted 2015 as the date by which it will have established a fisheries database and EAFM monitoring system.

Table 3 summarizes the progress in achieving the second target under Goal 2: Improved income, livelihoods, and food security for an increasingly significant number of coastal communities across the region through a new sustainable coastal fisheries and poverty reduction initiative commonly referred to as "COASTFISH."

Table 4 summarizes the progress in achieving EAFM Target 3: Putting in place measures for ensuring sustainable exploitation of shared tuna stocks, including protection of tuna spawning and juvenile growth areas.

Target 4 under Goal 2 of the NPOA is more effective management and sustainable trade in live reef fish and reef-based ornamentals. A draft national management plan for PNG's ornamental fishery has been formulated. The only existing analysis of the status of achievement of this target is out of date. A learning network group that will lead the analysis and define development partners' roles with greater civil society involvement is being created. Formulating a strategy for promoting the protection of spawning areas for species viable for the ornamental and live reef fish trade is under way.

**Table 3 Implementation Status of Initiatives under Target 2 of Goal 2 of the National Plan of Action**

Initiative	Performance Indicator	Status
2.2.1 Implement the Coastal Fisheries Management and Development Project in Milne Bay, Morobe, and New Ireland	<ul style="list-style-type: none"> <li>• Implementation commenced</li> <li>• Annual review of progress completed</li> <li>• Project completed</li> </ul>	Project is funded under the Asian Development Bank, but funding has not continued. Implementation by the National Fisheries Authority has not recommenced
2.2.2 Implement community-based fisheries management (CBFM) models	<ul style="list-style-type: none"> <li>• Project and program design completed</li> <li>• Implementation commenced</li> <li>• CBFM models adopted by communities</li> </ul>	Currently, it is being implemented by nongovernment organizations.
2.2.3 Mobilize significant new financial investments to support COASTFISH	<ul style="list-style-type: none"> <li>• Develop COASTFISH investment plans</li> <li>• Commence implementation of plans</li> <li>• Annual review of progress</li> </ul>	Not yet started
2.2.4 Channel funding through the National Fisheries Authority to the National Development Bank that targets promotion of micro- and small-scale fisheries	<ul style="list-style-type: none"> <li>• Policy proposal developed</li> <li>• Proposal endorsed</li> <li>• Implementation commenced</li> </ul>	Started
2.2.5 Upgrade Kavieng Fisheries College	<ul style="list-style-type: none"> <li>• Upgrade approved</li> <li>• Upgrade commenced</li> <li>• Upgrade completed</li> </ul>	Ongoing
2.2.6 Build marine aquaculture research station in Kavieng	<ul style="list-style-type: none"> <li>• Proposal developed and approved</li> <li>• Construction completed</li> </ul>	Ongoing and nearly complete
2.2.7 Improve marketing of marine products, including diversification and expansion of markets	<ul style="list-style-type: none"> <li>• Marketing strategy commenced</li> <li>• Marketing strategy completed</li> <li>• Strategy implementation commenced</li> <li>• Strategy in place</li> </ul>	Ongoing
2.2.8 Conduct quantitative assessment of bycatch (shrimp, tuna, other species)	<ul style="list-style-type: none"> <li>• Project design completed</li> <li>• Assessment commenced</li> <li>• Annual assessment of progress</li> <li>• Assessment completed</li> </ul>	Ongoing

Source: Author.

**Table 4 Implementation Status of Initiatives under Target 3 of Goal 2 of the National Plan of Action**

Initiative	Performance Indicator	Status
2.3.1 Build a sustainably managed tuna industry and maximize economic benefits from it	<ul style="list-style-type: none"> <li>• Tuna Fisheries Management Plan in place</li> <li>• Annual review of plan implementation carried out</li> <li>• Annual assessment of economic performance</li> </ul>	Ongoing
2.3.2 Conduct tuna stock assessments and research on the socioeconomic aspects of the tuna fishery	<ul style="list-style-type: none"> <li>• Project design completed</li> <li>• Stock assessments conducted</li> <li>• Annual reporting of assessment results</li> </ul>	Ongoing
2.3.3 Implement Vessel Monitoring System (VMS) for tuna fisheries	<ul style="list-style-type: none"> <li>• VMS designed</li> <li>• VMS implementation commenced</li> <li>• Annual review of implementation</li> <li>• VMS system in force</li> </ul>	Implemented and ongoing
2.3.4 Survey and analyze the present state of implementation with respect to current opportunities	<ul style="list-style-type: none"> <li>• Survey designed</li> <li>• Diagnosis and analysis process commenced</li> <li>• Draft report</li> <li>• Final report</li> </ul>	Not started
2.3.5 Create a learning network group to lead the analysis  Define partners' roles with greater civil society involvement (e.g., churches and development agencies)	<ul style="list-style-type: none"> <li>• Learning network designed</li> <li>• Learning network process commenced</li> <li>• Annual reporting on performance of network agencies</li> </ul>	Started
2.3.6 Build capacity of all local fishers in understanding the tuna fishery, including importance to long-term sustainability of protecting juveniles	<ul style="list-style-type: none"> <li>• Program designed</li> <li>• Program commenced</li> <li>• Annual reporting of performance</li> <li>• Final report</li> </ul>	Not Started
2.3.7 Promote and encourage protection of key tuna spawning areas (e.g., former Mogardo square)	<ul style="list-style-type: none"> <li>• Areas identified</li> <li>• Program for protecting sites developed</li> <li>• Program Implemented</li> <li>• Annual reporting of success</li> <li>• Final report</li> </ul>	Ongoing

Source: Author.

### Goal 3: Establishment and Effective Management of Marine Protected Areas

While PNG does not currently have large-scale MPAs, it has a large wildlife management area in Western Province (Maza Wildlife Management Area), which focuses on protecting turtles and dugong. In partnership with the PNG government, local communities, and development partners are collaborating on projects that will improve the effectiveness of the Maza Wildlife Management Area.

In early 2012, the PNG government released a policy discussion paper that addresses protected areas. Following consultation by a large number of stakeholders, a policy on protected areas has been drafted. The government plans wide public consultation with respect to the draft policy, out of which the broad framework for establishing PNG's system of protected areas will be developed. Once the government officially endorses the protected area policy, specific policies will be drafted with respect to MPAs.

To improve marine biodiversity and resource management in Kimbe Bay, the local communities, the West New Britain Provincial Government, and The Nature Conservancy have formulated and implemented an MPA network called Kimbe Bay Marine Management Area. Designed to be resilient to the negative impacts of climate change, this MPA is a network of 11 locally managed marine areas (LMMAs), each managed by community residents under an LMMA management plan. ADB is supporting the establishment of Kimbe Bay Marine Management Area through its technical assistance, Strengthening Coastal and Marine Resources Management in the Coral Triangle of the Pacific. Under this technical assistance, several coastal districts will serve as pilot sites for (i) improving community awareness of EAFM, (ii) establishing new LMMAs, (iii) improving the management capacity of existing LMMAs, and (iii) documenting lessons learned by LMMA managers and sharing these with the MPA network's membership.

LMMAs have also been established in other provinces such as Central, Madang, Manus, Milne Bay, and New Ireland. Once the MPA policy is formalized by the PNG government, these LMMAs will form part of an MPA system. A learning and training network relating to this MPA system has also been established.

### Goal 4: Application of Climate Change Adaptation Measures

The government's approach to addressing climate change is hazard-based. It has implemented initiatives that address coastal flooding, putting in place early warning systems, protecting coral reefs, assessing vulnerability to climate change, planting mangroves, and increasing community awareness of climate change issues. The Office of Climate Change and Development (OCCD) in the Central Province has performed climate change vulnerability assessments, as have some NGOs at specific project sites. Some organizations have planted mangroves as a cost-effective coastal protection measure, with some communities setting up nurseries to facilitate mangrove planting. Other communities have built stone walls to protect their coasts.

The OCCD-sponsored Millions of Mangroves Project aims to literally plant millions of mangrove trees. This project represents a significant leap in the scale and effectiveness of PNG community mangrove planting initiatives not only because of its impressive quantitative target, but also because it unites all stakeholders in the rehabilitation of mangroves. In 2011, OCCD hosted its first mangrove workshop under the project at the Motupore Island Research Centre. Subsequently, OCCD has supported multiplication of seed stock, and renovation of the center's mangrove nursery to support a mangrove distribution network. Other organizations have conducted mangrove training and awareness initiatives in local communities such as the WWF's programs in Madang and Manus provinces, and those of Ailan Awareness in New Ireland Province.

The ADB Coral Triangle Pacific Project aims to help local NGOs promote community-led climate change adaptation measures. The project has four objectives: (i) publish a climate change adaptation manual that will help local communities assess their vulnerability to the negative impacts of climate change; (ii) help these communities identify appropriate climate change adaptation options and evaluate the cost-effectiveness of each; (iii) help beneficiary communities test the effectiveness of the adaptation options they have chosen.; and (iv) document the results achieved to possibly replicate this exercise in all of PNG's maritime provinces.

# Management Issues

## Capacity Building

In Papua New Guinea (PNG), the five goals of the Coral Triangle Initiative (CTI) and the measures for achieving them that comprise the national plan of action (NPOA) are together referred to as the country's Marine Program. Ultimately, fulfilling the goals of this program will largely depend on the institutional capacity of the agencies and development partners who have committed to its implementation. The Department of Environment and Conservation (DEC), the National Fisheries Authority (NFA), and the Office of Climate Change and Development (OCCD) are the primary government agencies charged with implementing the NPOA. Other partners will help implement the program under the direction of the National Coordinating Committee (NCC) for the CTI. However, some of the key implementation agencies lack institutional capacity in a number of areas.

Established under a National Executive Council decision, the NCC is the coordinating unit for implementing the PNG Marine Program. NCC members are drawn from government line agencies, with one member representing national and international nongovernment organizations (NGOs), which have been invited to attend NCC meetings as observers since 2010.

In early 2010, the DEC established a CTI desk, with two staff members (an executive manager and one supporting staff member) assigned to implement the program. While the NFA is the lead agency in implementing the ecosystem approach to fisheries management, it has not yet clarified its capacity requirements for fulfilling this role. The OCCD is the lead agency for implementing the goal relating to climate change and adaptation measures; however, it also has not yet clarified its capacity requirements for fulfilling this goal. Other implementing partners of the PNG Marine Program include civil society organizations, provincial governments, local governments, and local communities. Of these partners, only civil society organizations appear to have the requisite capacity for implementing the programs to which they have committed. Training programs should improve the capacity of the other partners.

Table 5 summarizes the roles and responsibilities of each of the implementing partners of the PNG Marine Program.

Ongoing training and improvement of implementation capacity will be required to achieve PNG's marine resource management goals. In 2001, NGOs and other stakeholders convened a workshop to foster collaboration in meeting PNG's marine resource management capacity

**Table 5 Roles and Responsibilities of Papua New Guinea Marine Program Implementing Partners**

Organization/Body	Role	Responsibility
National Coordinating Committee (NCC)	Coordinating	Decision making, providing advice, reviewing and approving, endorsing
Department of Environment and Conservation (DEC)	<ul style="list-style-type: none"> <li>• DEC Secretariat as the focal point for Coral Triangle Initiative (CTI)</li> <li>• Leads in implementing CTI Goals 1, 3, and 5</li> </ul>	Coordinating, organizing, providing advice on overall program implementation, convening all CTI-related matters, funding
National Fisheries Authority	<ul style="list-style-type: none"> <li>• Secretariat for Technical Working Group</li> <li>• Leads in implementing CTI Goal 2</li> </ul>	Providing technical advice and expertise, informing NCC on technical matters relating to the implementation of CTI goals, funding
Office of Climate Change and Development	Leads in implementing CTI Goal 4	Providing advice on implementing CTI Goal 4, informing NCC on implementation of CTI Goal 4, funding
Provincial governments	Implementation in the provinces	Administration in the provinces, informing and advising on needs identified in the provinces, funding
Local governments	Implementation at local level	Administration at local level, link to local communities, funding
Civil society organizations	Implementation	Facilitators, training providers

Source: PNG Marine Program Strategic Plan.

requirements. A direct outgrowth of that workshop was the Strengthening Conservation Capacity Project, and the production of eight training modules led by the project. A similar workshop convened in October 2010 at the March Girls Resorts in Port Moresby resulted in the formation of the PNG Learning and Training Network. The purpose of this network is to ensure that all conservation and resource management practitioners possess the necessary capacity to fulfill the resource management roles to which they have committed. In 2006 and again in 2011, the NFA and the National Fisheries College conducted a training needs assessment, which identified the training and institutional capacity requirements for efficiently developing and managing PNG's fishing industry.

Currently, civil society organizations perform most training in marine resource conservation and management, and many of them have shifted their focus from working with local communities and development partners to providing training. As a result, civil society organizations have trained residents of many coastal communities, on topics such as community engagement, formulation of management plans, biological monitoring of habitats adjacent to local communities, conflict resolution and management, ecosystem approach to fisheries management, performing socioeconomic surveys, mangrove rehabilitation and management, and numerous related topics. As coastal communities become more organized in their marine resource management efforts, they are increasingly able to identify the types of training they require to successfully manage the resources of

which they are stewards. Training in locally managed marine areas and related managerial structures are key in this regard.

Currently, the most pressing capacity shortfalls in implementing sustainable marine resource management are as follows:

- (i) **Leadership.** In communities with dedicated leaders, substantial progress has been achieved in implementing the PNG Marine Program. Visionary leadership appears to be key to successful implementation of the marine program in the community, local, provincial, and national levels.
- (ii) **Managers.** While turnover in marine resource management positions remains relatively high, women have increasingly taken up management positions in organizations focusing on conservation and resource management, civil society organizations in particular. The PNG Learning and Training Network will hopefully advance peer learning among the managers of organizations charged with implementing the marine program. The fact that half the authors of this report are managers of government agencies and civil society organizations that focus on conservation and marine resource management bodes well in this regard.
- (iii) **Technical expertise.** While PNG has technical experts capable of implementing the marine program, these experts are few in number compared with the requirements of implementing the program. Their ability to participate fully in collaborative conservation and resource management efforts is thus limited. For example, it was exactly this constraint that delayed the preparation of this report.

Several organizations are currently providing education and training that relate to conservation and marine resource management: University of Papua New Guinea, Unitech, University of Natural Resources and Environment, National Fisheries College, various private institutions, and civil society organizations.

## Financial Considerations

As cost schedules or budgets for existing marine protected areas are unavailable at this writing, it is not possible to provide a detailed cost for implementing the five goals of the CTI or the PNG Marine Program. Central coordination among CTI stakeholders is lacking; and not all specific objectives of each CTI goal are specific, measurable, attainable, realistic, or timely enough to accurately estimate their implementation costs. The program also lacks specific measurable targets for the number, size, and degree of coverage of the proposed marine protected areas. It is not currently possible to accurately estimate the cost of creating and maintaining them.

Ultimately, the appropriate institution for formulating an appropriate financial strategy for financing the PNG Marine Program is the NCC, if it receives appropriate assistance from the CTI. However, some progress in this regard has been achieved through the Asian Development Bank (ADB) technical assistance to the DEC, which has proposed costing templates for marine protected areas.

The PNG Marine Program calls for support from all national and international donors and development partners, including bilateral donors. However, bilateral support generally funds

initiatives implemented at the regional rather than at the country level. As a result, PNG looks to multilateral donor agencies to provide the support necessary for implementing its national marine resource management initiatives. Such multilateral donors include ADB, the Global Environment Facility (GEF), the United Nations Development Programme (UNDP), and the United Nations Environment Programme (UNEP). The fact that these donors have been part of the CTI since its inception in 2007 also creates a tendency to view international donors in this light.

These international donors have provided PNG with considerable support to conservation and resource management. GEF has allocated funds for projects targeting biodiversity conservation, and some of these funds were further allocated to implementing marine biodiversity management programs. For example, ADB was designated as the implementing agency for some of these programs under its technical assistance on Coastal and Marine Resources Management in the Coral Triangle in the Pacific.

The United States is providing marine resource management funding through an NGO consortium known as the Coral Triangle Support Program. The program's major focus in PNG is implementing the CTI Goal 4. In this regard, the program will closely collaborate with the NFA in implementing ecosystem approach to fisheries management (EAFM) activities. Other aspects of this initiative within the EAFM framework include marine protected area management and climate change adaptation and resilience. The Australian government provides support to this initiative through its Department of the Environment, Water, Heritage and the Arts.

A major focus in implementing the PNG Marine Program is maximizing positive impacts from the deployment of available resources, which replicates and sustains such impacts over the long term. Such a focus also promotes an integrated approach to marine resource management. Table 6 summarizes the sources of funding currently provided for implementing PNG's NPOA, while Table 7 summarizes potential sources of such funding.

**Table 6 Sources of Current Funding for Implementing Papua New Guinea's Marine Program**

Funding Source	Donor	Amount (\$ million)	Duration (years)
ADB Technical Assistance	Global Environment Facility	6.6	4
Coral Triangle Support Program	United States Agency for International Development	1.4	4
Australian Government's DEWHA	Government of Australia	-	3
Marine Program	Government of Papua New Guinea	3.0	4

ADB = Asian Development Bank; DEWHA = Department of the Environment, Water, Heritage and the Arts.

Source: Author.

**Table 7 Sources of Potential Funding for Implementing Papua New Guinea's Marine Program**

Type of Funding	Source
Multilateral	Global Environment Facility; Food and Agriculture Organization of the United Nations; African, Caribbean, and the Pacific Group of States
Bilateral	Australian Aid, New Zealand Aid, Japan
International nongovernment organizations	The Nature Conservancy, WWF, Conservation International, World Conservation Society
International foundations	Packard Foundation, Macarthur Foundation
Payments for environmental services	Downstream users, water consumers
Park user fees	Individuals, tourists, researchers
Privatization of park services	Tour operators, private sector
Debt for nature swaps	Donors, government, nongovernment organizations
Environmental levies	Individuals
Government contributions	Government
Hotel occupancy taxes	Hotel clients
Cruise ship fees	Passengers
Fines	Individuals, corporations
Permit and license fees	Fishers, hunters, researchers
Biodiversity prospecting	Pharmaceutical companies
Carbon sequestration payments	Corporations, government
Green investments	Corporations
Fish catch and service levies	Commercial fishers

Source: Author.

## Public Awareness

A wide variety of organizations promotes public awareness of the need for sustainable marine and coastal resource management in PNG:

**Ailan Awareness.** Formally established in 2005, Ailan Awareness has promoted public awareness of marine resource management issues in New Ireland since 1993. This organization uses drama, song, and dance to disseminate information relating to marine ecosystems, community-based resource management, unsustainable and destructive fisheries practices, and climate change. Ailan Awareness is also the focal point for the Learning and Training Network in New Ireland, and likewise helps communities develop locally managed marine areas.

**Mahonia Na Dari (MND, or Guardian of the Sea).** MND is a local conservation education NGO based in Kimbe, West New Britain Province. In operation for 15 years, MND's major initiative is the Marine Environment Education Program, which targets students and teachers in West New Britain. In Kimbe Bay communities, it also conducts education awareness programs, which focus on marine ecosystems, sustainable fishing practices, impacts of alternative land use regimes,

and benefits of marine protected areas. MND has a research facility that supports marine biologists worldwide in partnership with James Cook University, Australia. Visiting researchers train staff in marine biology, ecosystems, marine species, impacts of climate change on marine life, and ecosystems in general. Such programs increase staff knowledge in these topics, and disseminate information to schools and local residents.

**PNG Centre for Locally Managed Areas.** This national conservation NGO was formally established in 2008. It is part of the locally managed marine area (LMMA) network in the Pacific region, which also includes Indonesia and the Philippines. The centre primarily promotes community self-reliance through management of community-owned or -managed resources.

**Mas Kagin Tapani, (MAKATA, or Ocean Stewards and Guardians).** MAKATA is a community-based organization established in 2009 that works in the coastal communities of Madang Province. Its initial focus on protection and management of leatherback turtles has expanded to include awareness programs on leatherback turtle conservation, and other aspects of marine conservation and resource management including climate change. As its target audience includes schools and local communities, MAKATA educates members of local communities in a broad range of livelihood issues, such as ecotourism, small business development, and financial literacy.

**The Nature Conservancy.** This conservation NGO based in the United States (US) has been active in Kimbe Bay since 1993. Its major focus is the development of a marine protected area network, the member areas of which will ultimately be resilient to the negative impacts of climate change. The Nature Conservancy is currently applying the lessons it has learned from its Kimbe Ridge-to-Reef Program in Manus Province.

**Seaweb.** It is a US-based communications and/or media organization that focuses on conservation of marine resources. Since 2003, Seaweb uses its PNG office to provide communications training to organizations and persons involved in information dissemination. Its ultimate objective is to educate local residents and the public on the importance of protection and management of marine resources. The ultimate goal of such education is community-based public action that targets this objective.

No statistics are available regarding the exact number of people Seaweb has reached through its awareness programs over the past 15 years. However, it has likely reached a minimum of 40% of its target population, including students and residents of local communities in PNG's coastal provinces. In the highlands, Seaweb reaches students through the curricula of local schools. It also promotes awareness of the need for conservation and natural resource management through media including newspapers, radio, television programs, posters, brochures, and awareness visits conducted by environment and natural resource-oriented organizations.

The awareness programs described above have produced the following results:

- (i) Communities in several areas have agreed to set aside management areas.
- (ii) Some communities are now able to make informed decisions concerning unsustainable management of fisheries resources. Some provinces in which Seaweb operates have entirely ceased operations in the live reef food fish trade.
- (iii) Residents of many communities have begun to challenge large-scale development initiatives and their negative impacts on the local environment.

- (iv) The attitude of local residents toward unsustainable fishing practices has changed from one of indifference to one of resolve.
- (v) Local conservation champions have emerged and educated members of their communities.
- (vi) In some jurisdictions, marine resource management laws have been passed in local government.
- (vii) Collaborative partnerships between national and provincial government agencies that focus on conservation and management of the marine resource are coalescing.
- (viii) Students exposed to marine education and awareness programs have begun entering professions, or are being employed by organizations that promote environmental protection.
- (ix) Women are beginning to lead conservation efforts in local communities.

The organizations have identified the following constraints to marine conservation and resource management in PNG:

- (i) lack of effective enforcement of marine guidelines and laws proclaimed under LMMA management plans,
- (ii) lack of capacity for educating local communities in social issues that negatively impact the environment,
- (iii) lack of communication skills among the officers and staff members of public awareness organizations,
- (iv) lack of technical and scientific expertise in responding to questions posed by community residents,
- (v) inadequate funding,
- (vi) logistical problems such as those relating to transport and communications, and
- (vii) lack of coordination between stakeholders in program implementation and administration.

However, the following lessons have been learned from the organizations' collective experience:

- (i) Regular monitoring is required to compile accurate statistics regarding the number of people these organizations reach.
- (ii) All public awareness organizations require a monitoring and evaluation framework.
- (iii) Coordination among public awareness organizations must be improved for uniformity regarding the information disseminated to local communities.
- (iv) A course in marine resource management for public awareness officers is necessary to ensure that they can appropriately disseminate information regarding such issues to members of local communities.
- (v) Training in communications skills is also required for public awareness officers if they are to disseminate information efficiently.
- (vi) The approach taken by public awareness officers in disseminating information to local communities must be culturally appropriate.
- (vii) The efforts of public awareness officers could be magnified by encouraging media organizations to include conservation-related issues or stories in their coverage.
- (viii) Sustainable funding for public awareness is necessary for such programs to expand.

The lessons identified above may be summarized in the following recommendations:

- (i) **Coordination of activities.** A coordinating group or learning and training network (LTN) should coordinate public awareness initiatives relating to conservation or marine resource management. A workshop should be organized for all organizations concerned with such issues, including those that can provide appropriate trainers. The agenda at this workshop should be comprehensive and the approach interactive so that benefits resulting from the workshop are maximized.
- (ii) **Coordinated capacity building.** The LTN or a similar group should coordinate capacity-building efforts, with the most competent partners providing training in capacity building.
- (iii) **Database.** DEC is the central coordinating agency for marine conservation and resource management initiatives in PNG. The CTI, NCC, and all NPOA implementing partners should support the DEC in developing a database relating to such issues and initiatives.
- (iv) **Collaboration.** Conservation and resource management overlap with other issues that impact local communities in PNG. It is vital that government departments with jurisdiction over such diverse areas as agriculture and livestock, commerce and industry, ports, and public information help promote sustainable resource management and livelihoods in local communities.
- (v) **Statistics.** A means of determining the number of people reached by conservation and resource management initiatives should be developed, preferably by a coordinating group that serves all organizations active in conservation and marine resource management.
- (vi) **Sustainability.** Public awareness should be a regular component of all conservation and resource management initiatives. Organizations focusing on such issues should be provided with funding sufficient to implement regular public awareness programs.
- (vii) **Link to the PNG Marine Program.** Marine conservation public awareness organizations should be made familiar with both the PNG Marine Program Strategic Plan and CTI. This would allow them to align their programs and funding with the objectives and goals of PNG's Marine Program.
- (viii) **Engagement.** Marine conservation public awareness organizations should develop a process that encourages local residents to discuss marine conservation and resource management issues on a regular basis.
- (ix) **Training in community issues.** The coordinating group referred to above should work with partners outside organizations that primarily focus on conservation and marine resource management. The focus of such interaction should be awareness among the staff of these target organizations of the issues they address that might impact the marine environment.
- (x) **Funding.** Funding must be readily available to marine conservation public awareness organizations if they are to promote community action and enforce laws and regulations that protect the marine environment and sustain the livelihoods of residents of coastal communities.

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## State of the Coral Triangle: Papua New Guinea

One of a series of six reports on the status of marine resources in the western Pacific Ocean, the *State of the Coral Triangle: Papua New Guinea* describes the biophysical characteristics of Papua New Guinea's coastal and marine ecosystems, the manner in which they are being exploited, the framework in place that governs their use, the socioeconomic characteristics of the communities that use them, and the environmental threats posed by the manner in which they are being used. It explains the country's national plan of action to address these threats and improve marine resource management.

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