STATE OF THE CORAL TRIANGLE:
Solomon Islands

ADB

CORAL TRIANGLE INITIATIVE
ON CORAL REEFS, FISHERIES AND FOOD SECURITY

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Contents

Tables and Figures

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
Director General
Pacific Department
Asian Development Bank

Acknowledgments

This report was prepared by Reuben J. Sulu (University of the South Pacific and WorldFish Center); Delvene N. Boso (WorldFish Center); Agnetha Vave-Karamui (Solomon Islands Ministry of Environment, Climate Change, Disaster Management and Meteorology); Senoveva Mauli (The Nature Conservancy); Lysa Wini-Simeon (World Wide Fund for Nature, Coral Triangle Support Partnership; and Solomon Islands Ministry of Environment, Climate Change, Disaster Management and Meteorology).

As limited human and financial resources, as well as time constraints, prevented nationwide consultations and extensive data processing and analysis, this report was mostly prepared from desktop reviews. In this regard, we acknowledge the extensive support provided by our numerous colleagues from a wide range of institutions and government agencies. These include the following: (i) the Asian Development Bank's regional technical assistance project team; (ii) Solomon Islands National Coordinating Committee of the Coral Triangle Initiative; (iii) Solomon Islands Ministry of Environment, Conservation, Disaster Management and Meteorology; (iv) Solomon Islands Ministry of Fisheries and Marine Resources; (v) WorldFish Center; (vi) World Wide Fund for Nature; (vii) United States Coral Triangle Initiative Support Program; (viii) Coral Triangle Support Partnership; (ix) The Nature Conservancy; and (x) The University of the South Pacific.

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Executive Summary

Biophysical Characteristics

The Coral Triangle's easternmost country, Solomon Islands, is a double-chained archipelago of approximately 990 islands. While the country's total land area is only 28,000 square kilometers (km^2), its oceanic area is vast, totaling 1,340,000 km^2. The country's six major islands are rugged and mountainous, with deep internal valleys and steep terrain that descends sharply into ocean depths. All six major islands are volcanic in origin, and are surrounded by barrier, patch, lagoon, or fringing reefs, the total coral reef area of Solomon Islands being 3,591 km^2. For the most part, the country's smaller islands are raised coral and atolls.

Solomon Islands has distinct wet and dry seasons, with an annual average temperature of 27°C. During the dry season from April to November, southeast trade winds (*ara*) blow continually with varying intensity. The remainder of the year is the wet season, with winds blowing from the west to northwest (*koburu*). Most tropical cyclones that impact Solomon Islands occur during the wet season.

Solomon Islands has one of the most diverse coral reef systems in the world, due to its highly varied marine habitat. The country's coral reefs are mainly fringing and intermittent around all the islands. At least 485 coral species belonging to 76 genera have been observed in Solomon Islands waters, which are likewise home to at least 1,019 fish species belonging to 82 families. The composition and diversity of the country's fish community are thought to be influenced by habitat type and food availability. The greatest degree of species diversity is found in the western part of the country. Large marine vertebrates—including eight whale species, nine dolphin species, and one dugong species, as well as five species of turtle and one species of crocodile—have been reported in Solomon Islands waters.

Information on marine invertebrates like mollusks, sea cucumbers, and sponges is limited to the aquaculture of a few species of economic value. Sea cucumbers have historically been an important commodity in Solomon Islands, as these were processed and exported to Asian markets as a delicacy. However, their overexploitation has caused target populations to decline, which ultimately resulted in the closure of the sea cucumber fishery.

Mangrove forests are well distributed across the country, and occupy a total area of about 65,000 hectares. Some 30–32 species are present. Coastal community residents rely on mangroves for both food and wood. Seagrass beds occupy about 10,000 hectares and include at least 10 species. Residents of coastal communities depend on seagrass beds for harvesting specific types of seafood, rabbitfish in particular.

Governance

Successive governments have included protection and sustainable use of coral reefs in their policy frameworks. Thus, a substantial number of policy documents addressing sustainable use of resources provide the framework for national strategies that support inshore fisheries management, conservation, climate change adaptation, and adoption of the ecosystem approach to fisheries management. The country is a party to several regional and international environmental agreements that oblige it to protect, sustainably use, and manage coral reefs and marine resources in general.

The major mechanisms for traditional marine resource management are

(i) access control through customary marine tenure arrangements;
(ii) traditional ecological knowledge relating to resource management;
(iii) prohibitions against access to, and exploitation of resources within culturally significant geographic areas; and
(iv) prohibitions against consumption of certain species.

Traditional practices relating to access control and/or prohibitions vary within and across locales. Further, increased modernization, the shift to a cash economy, and changing beliefs and attitudes have weakened traditional management systems. All these changes have significantly impacted Solomon Islands fisheries.

Laws such as the Fisheries Act (1998), the Wildlife Protection and Management Act (1998), the Shipping Act (1998), the Environment Act (1998), and the Protected Areas Act (2010) provide the legal basis for marine environmental protection, and sustainable use and management of the marine resource. However, local compliance remains a challenge. A number of factors result in poor compliance in the communities. These include the need to meet daily subsistence demands, the desire to generate cash income, poor enforcement capacity, and deficiencies in science-based decision making. Greater efforts are required at the rural level if the country's coral reef resources are to be sustainably managed.

Socioeconomic Characteristics

In 2011, Solomon Islands had a population of 516,000 and an annual population growth rate of 2.3%, with urban populations growing faster than those in rural areas because of rural–urban migration. Only 15.7% of the population was employed, the remainder being categorized as either subsistence or unpaid workers. About 80% of the population lived in rural areas, mostly along the coast. A subsistence economy prevailed in these areas, with coastal fisheries playing a vital role in the livelihood of local residents. Nearly half of all women and 90% of all men were engaged in fishing. Most rural fishers sold their catch solely to meet household needs; however, some fishers also sold their catch in urban areas. Small-scale coral reef–based commercial fisheries included the ornamental fish trade, the trochus fishery, the sea cucumber fishery (currently closed), and the reef fish fishery. Commercial fisheries mainly targeted tuna, and generated an average annual revenue of $4.5 million for the government from the licensing of domestic and foreign fleets. The total catch increased over the past decade

due to the growth of the foreign fishing fleet, though the domestic fleet shrank in size. The major species targeted by commercial fishing were skipjack and yellowfin tuna.

Threats and Vulnerabilities

The country's coral reefs are threatened by and vulnerable to overfishing as a result of population growth, destructive fishing practices, and sedimentation and runoff of excessive nutrients from logging. Emerging concerns include the negative environmental impacts of aquaculture, mining, industrial activities (e.g., shipyards, fish factories, canneries, and light industry); disposal of untreated sewage directly into the marine environment; transboundary issues (e.g., transport of commodities across international boundaries and conservation of migratory species); harmful algal blooms; marine invasive species; and climate change impacts (e.g., ocean acidification, coral bleaching, and coral disease). Several species (e.g., whales and dolphins) are threatened, which calls for their management and protection. While coastal tourism development is currently limited, mining of corals for construction purposes (e.g., building of coastal structures such as seawalls and seaward extensions) is a growing concern.

National Plan of Action Initiatives and Future Plans

The Solomon Islands National Plan of Action (NPOA) for the Coral Triangle Initiative for Coral Reefs, Fisheries, and Food Security—commonly known as the Coral Triangle Initiative, or CTI—guides management of the country's coral reefs and related ecosystems. In collaboration with nongovernment organizations (NGOs) and development partners, the government currently sponsors a wide range of conservation, education, and public awareness initiatives.

The CTI has five goals. Goal 1 aims to designate and effectively manage priority seascapes. To achieve this goal, Solomon Islands has declared the Bismarck-Solomon Seas Ecoregion a priority seascape. In 2006, Solomon Islands, Indonesia, and Papua New Guinea signed a memorandum of understanding that declared a transboundary partnership for sustainably managing said ecoregion. A regional action plan was then formulated to guide the conservation of the endangered leatherback turtle in this priority seascape.

Goal 2 aims to apply an ecosystem approach to the management of fisheries and other marine resources. As of this writing, Solomon Islands has no policies and regulations that specifically address implementation of the ecosystem approach to management of marine resources. Nevertheless, some principles of the ecosystem approach to fisheries management are reflected in the Fisheries Act (1998), the country's fisheries regulations, and its management plans for particular resources. Further, at the community level, the "ridges-to-reef" approach to resource management, which is a form of ecosystem-based fisheries management, is currently being tested. Under this initiative, environmental threats and opportunities for sustainable use of both terrestrial and marine ecosystems have been mapped for Malaita Province, and priority conservation sites identified. Provincial governments are also conducting fisheries policy reviews, with some provinces having already proceeded to the subsequent step of preparing fisheries ordinances that reflect the ecosystem approach to fisheries management.

Goal 3 aims to establish and effectively manage marine protected areas (MPAs). With regard to improving the management of MPAs, Solomon Islands' NPOA recognizes customary marine tenure, which is a form of locally managed marine areas (LLMAs) and are a widely accepted form of marine resource management in the country. As a result, management of MPAs builds on the strengths of local and traditional forms of resource management by making residents of local communities aware of the potential benefits of modern community-based resource management. Finally, Solomon Islands has a network that coordinates management of all LLMAs.

Goal 4 aims to apply climate change–adaptation measures. Drafted in 2009, the Solomon Islands National Adaptation Program of Action identifies vulnerable sectors as agriculture and food security; water supply and sanitation; education, awareness, and information; human settlements; human health; waste management; fisheries and marine resources; infrastructure; and coastal protection. A number of climate change–adaptation projects are in progress. Most of these are coordinated or managed by churches, NGOs, or various government agencies.

Goal 5 aims to improve the status of threatened species. In fulfilling this goal, Solomon Islands is guided by numerous national, regional, and international frameworks and strategies.

Because fish constitute the major source of animal protein in the diet of most Solomon Islanders, population growth will likely increase coastal fishery extraction rates. However, a growing body of both scientific and anecdotal evidence suggests that current extraction rates have reached unsustainable levels, as a decrease in catch in some fisheries has been observed in highly populated areas and market centers. As a result, the estimated output from the entire national coastal fisheries resource may already be unable to meet future demand for fish. This is particularly important since in addition to being the country's major source of animal protein, fish are likewise a source of cash income for many Solomon Islanders and a primary source of food security for the country.

In this regard, regional and national initiatives such as the CTI are addressing overexploitation of the country's coral reef fisheries. The Solomon Islands NPOA thus incorporates numerous management actions that are both consistent with CTI regional goals and sustainable use of the country's fisheries. These actions address conservation of the country's coral reefs, sustainable use of the country's fisheries resource, and food security. While significant efforts at all levels have thus far been undertaken to protect and sustainably utilize the country's coral reefs and the fisheries associated with them, much more action in this regard is required if the environmental threats identified above are to be mitigated.

Abbreviations

ACMCA	–	Arnavon Community Marine Conservation Area
ADB	–	Asian Development Bank
BSSE	–	Bismarck-Solomon Seas Ecoregion
CBRM	–	community-based resource management
CBSI	–	Central Bank of Solomon Islands
CCA	–	climate change adaptation
CMT	–	customary marine tenure
CPUE	–	catch per unit of (fishing) effort
CSIRO	–	Commonwealth Scientific and Industrial Research Organisation
CTI	–	Coral Triangle Initiative on Coral Reefs, Fisheries, and Food Security (also referred to as Coral Triangle Initiative)
CTSP	–	Coral Triangle Support Partnership
EAFM	–	ecosystem approach to fisheries management
ECD	–	Environment and Conservation Division
EU	–	European Union
FSPI	–	Foundation for the Peoples of the South Pacific International
ha	–	hectare
IUCN	–	International Union for the Conservation of Nature
JICA	–	Japan International Cooperation Agency
kg	–	kilogram
km	–	kilometer
km^2	–	square kilometer
LLMA	–	locally managed marine area
MECDM	–	Ministry of Environment, Climate Change, Disaster Management, and Meteorology
MECM	–	Ministry of Environment, Conservation and Meteorology
MFMR	–	Ministry of Fisheries and Marine Resources
MPA	–	marine protected area
NCC	–	National Coordination Committee (for the Coral Triangle Initiative)
NGO	–	nongovernment organization
NPOA	–	National Plan of Action
PES	–	payment for ecosystem services
PNG	–	Papua New Guinea
RFC	–	rural fisheries center

SILMMA	–	Solomon Islands Locally Managed Marine Area (Network)
SPREP	–	Secretariat of the Pacific Regional Environment Programme
TEK	–	traditional ecological knowledge
TNC	–	The Nature Conservancy
WWF	–	Worldwide Fund for Nature (formerly World Wildlife Fund)

Introduction

The Coral Triangle describes a marine expanse that straddles the Indian and Pacific oceans. This area is known to environmentalists to be extremely abundant of marine life and significant biodiversity. With regard to political boundaries, 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—such as food, income, recreation, and culture—to the 360 million residents of the Coral Triangle, particularly its 120 million residents who live on or near the region's coastlines. These also protect both the coastline and its residents from the damaging impact of extreme weather events.

Due to the numerous benefits they provide, coral reefs are central to the livelihood of most Solomon Islanders. However, little reliable information concerning the ecology of these ecosystems is available. In fact, most of the information available derives from a handful of studies conducted over the past 10 years. Thus, even though many Solomon Islands coral reef species are being extracted for both subsistence and cash-income purposes, little is known about their rates of extraction. Nor are baseline data on the extent of these species available against which the sustainability of alternative rates of extraction could be assessed. Similarly, existing research regarding the long-term impact of development-related activities on the country's coral reefs is scant. While two such studies have assessed the impact of logging on the country's coral reefs, as of this writing, no studies have assessed the impact of mining, shipping, or other development-related activities on the country's coral reef systems.

Ultimately, reliable baseline data are necessary for determining the overall ecological status of the country's coral reefs over time, as well as the sustainable rates of extraction of the specific species that inhabit them. However, the availability of such data is limited, and that which exist are collectively housed at numerous government agencies and nongovernment organizations (NGOs). In many cases, these data are protected, and thus unavailable for inclusion in this report. Even in cases where data are available, most of these exist only in raw, unprocessed form, or in a format unsuitable for processing. As a result, only those data that could be processed and analyzed within the time and resource constraints of this study were included in this report. Finally, in some cases, conflicts exist between the data available from the country's government agencies and those reported by international institutions. In such cases, the authors preferred

data reported by Solomon Islands' government agencies, as they were deemed to be more timely and accurate.

In short, this report summarizes all readily available information concerning Solomon Islands coral reefs and marine resources. This includes data and information on (i) the flora and fauna that inhabit the country and the manner these are utilized; (ii) the institutional arrangements for managing these resources; (iii) current coral reef conservation issues; and (iv) ongoing initiatives for addressing these issues, including in particular the Solomon Islands National Plan of Action (NPOA) for meeting the goals of the CTI.

Several factors drive the current rates of extraction of the country's marine resources. In addition to its relatively rapid rate of growth, the country's population is concentrated in rural coastal areas where subsistence-based economic activity predominates. In these locales, cash incomes often derive from direct harvesting and sale of coral reef resources. Second, degradation of the country's marine resource also results from development-related activities such as logging, expansion of tourist-related activity and infrastructure, plantation-related activities, mining, and urban development. Finally, climate change has reduced the extent of these resources to levels that fall short of those that would otherwise exist.

The above notwithstanding, since the year 2000, Solomon Islands has achieved some progress in moving toward sustainable rates of extraction of its marine resources. This progress in particular includes (i) a growing understanding of the consequences of unsustainable rates of extraction of these resources; (ii) enactment of legislation and formulation of policies for protecting the country's coral reefs; and (iii) national and regional initiatives for protecting, sustainably utilizing, and conserving the country's coral reef resources by government, donor agencies, and NGOs. However, additional efforts such as these are required if current rates of extraction of the country's marine resources are to reach sustainable levels, given the three factors referred to above that mitigate against this.

Biophysical Characteristics

Physical Geography

The Coral Triangle's easternmost country, Solomon Islands, is a double-chained archipelago of about 990 islands that faces the broad expanse of the Pacific to the east, and Papua New Guinea (PNG) to the west. Geographically located between 5° and 12° south of the equator, and 152° and 170° east, the country's numerous islands are roughly oriented in a northwest–southeast direction along the western margin of the Pacific plate.

The country's six major islands are Choiseul, Guadalcanal, Makira, Malaita, New Georgia, and Santa Isabel. These are rugged, mountainous islands with deep internal valleys and steep terrain that descends sharply into ocean depths. All six major islands are volcanic in origin, and are surrounded by barrier, patch, lagoon, or fringing reefs. In contrast, the country's smaller islands are mostly raised coral islands or atolls. Solomon Islands' continental shelf area is quite small. The country's total land area is only 28,000 square kilometers (km^2), although its oceanic area totals 1.3 million km^2. Technically speaking, Temotu, the country's easternmost province, falls outside the Coral Triangle.

Geologically, Solomon Islands lies along the southwestern border of the Pacific Ocean, where Pleistocene, recent, and contemporary volcanoes are notable features of the landscape of several major islands, New Georgia in particular. While the country's six major islands probably share similar evolutionary patterns, their structural characteristics differ considerably. The analysis of Falvey et al. (1991) reflects this, as this study divides the country into three geological provinces: Pacific, Central, and Volcanic, although this taxonomy excludes the Santa Cruz group of islands. Choiseul, Guadalcanal, and San Cristobal islands are intensely faulted, as they show no significant folding. In contrast, folding dominates Malaita and Santa Isabel islands. Geologically the youngest of the group, New Georgia consists of a number of Pleistocene to recent volcanic cones that are only 5 million–6 million years old (Coleman 1989).

The coral reefs that intermittently surround the country's islands are mostly of the fringing type. Even areas that on the map appear to be free of coral reefs (e.g., the northern and southern coasts of Guadalcanal) usually support a narrow fringing zone of corals on the steeply sloping seabed. The only areas completely devoid of corals are sandy beaches and areas near the mouths of major rivers. Long barrier and expansive intertidal reef flats are uncommon in Solomon Islands. Ontong Java—the country's only large atoll—is a northern outlier in this regard, as its length is 70 km, and its width varies from 11 km to 36 km. Similarly atypical, Sikaiana Atoll (Steward Islands), which is located 200 km northeast of Malaita, is a triangular

atoll about 10 km wide. The reefs surrounding these atolls drop off steeply into ocean depths, while raised atolls of significant elevation (e.g., Rennell and Bellona) have high coastal cliffs and fringing reefs along their coastlines.

Some of Solomon Islands' largest coral reef areas occur where large lagoon complexes are protected by volcanic islands, raised islands, sand cays, or barrier reefs. The country has numerous areas of this type, including those (i) located in the vicinity of the Shortland Islands near Bougainville; (ii) along the northeastern coast of Choiseul; (iii) on both sides of Manning Strait between Choiseul and Santa Isabel islands; (iv) in Gizo, on Vonavona island, and the lagoon area on New Georgia island; (v) in the vicinity of Vangunu in southeastern New Georgia, and along the northeastern coast past Ramata at the northern end of Malaita Province (Lau lagoon); and (vi) in the eastern part of Guadalcanal island. Submerged barrier reefs are uncommon in Solomon Islands.

Two major climatic systems affect Solomon Islands. These are (i) the southeasterly trade winds (*ara*) that predominate from May to October, and (ii) the northeasterly monsoon winds (*koburu*) that predominate from December to March. The *ara* season normally coincides with the dry season, which lasts from April to November, while the *koburu* season coincides with the wet season during the remainder of the year. The country's annual average (mean) temperature is 28°C. The daytime maximum temperature is typically 30°C, though the minimum temperature during the *ara* season can fall as low as 23°C. Annual rainfall ranges from 3,000 millimeters (mm) to 5,000 mm.

Coastal and Marine Ecosystem Biodiversity

A 1965 survey of coastal and marine biodiversity conducted by the British Royal Society compared Solomon Islands with other western tropical Pacific islands in an effort to establish significant biogeographic relationships. Sulu et al. (2000) reviewed this study along with all existing earlier studies, many of which were performed sporadically. The first comprehensive baseline survey of the country's marine biodiversity was Green et al. (2006). Conducted in 2004, this 5-week marine survey addressed the extent of marine biodiversity in the coastal areas surrounding the country's nine major islands. This study thus excluded Bellona and Rennell islands, as well as Temotu Province, which technically sits outside the eastern edge of the Coral Triangle.

In short, Green et al. (2006) conclude that Solomon Islands has one of the most diverse coral reef systems in the world. Veron and Turak (2006) attribute this significant degree of biodiversity to the wide variation in marine habitat types of these islands. Interestingly, in many cases, these widely varying marine habitat types lie geographically adjacent to one other. These thus appear to be unrelated to their respective geographic locations, or to distinctive features of the corals themselves. The description of the biodiversity of Solomon Islands coral reefs that appears below is summarized from Green et al. (2006), as well as other available data and information.

Seagrass beds

An important ecological feature of seagrass beds is their ability to bind sediments together and reduce erosion. In fact, seagrass beds that lie inshore from coral reefs trap most of the sediment carried by rivers and streams, and thus limit the amount of sediment deposited on corals. This

is an important feature of coral ecology, since sediment deposits inhibit the rate at which corals grow by reducing access to sunlight. Seagrass beds thus play an important role in protecting the health of coral reefs and, by extension, the marine life that depends on them for their survival. Seagrass beds are likewise feeding grounds for numerous marine species including fish, turtles, and dugongs, the latter being a large herbivorous mammal that feeds almost exclusively on seagrass. Interestingly, seagrass beds are even vital to the livelihood of some human communities. For example, in Lau Malaita, rabbitfish (*Siganus* spp.) are a significant source of animal protein for the local populace. The fact that annual rabbitfish spawning aggregations occur almost exclusively in seagrass beds means that such habitats ultimately play an extensive role in the survival of even human communities.

Seagrass beds are significant coastal habitats in Solomon Islands, in all occupying at least 10,000 hectares (ha). McKenzie et al. (2006) found that seagrass habitats in Solomon Islands (i) extend from the intertidal to the subtidal zones, and (ii) are also located along mangrove coastlines, estuaries, shallow embayments, and in coral reef, inter-reef, and offshore island locations. Similarly, this study confirmed the presence of 10 species of seagrass, which represent 80% of the known seagrass species of the Indo-Pacific region. These 10 species include *Cymodocea rotundata, Cymodocea serrulata, Halodule uninervis, Syringodium isoetifolium, Thalassodendron ciliatum, Enhalus acoroides, Halophila decipiens, Halophila minor, Halophila ovalis,* and *Thalassia hemprichii*.

Algae

Womersley and Bailey (1970) confirm 233 species of algae in Solomon Islands. These recomposed of 14 Cyanophyta species, 121 Rhodophyta species, 27 Phaeophyta species, and 71 Chlorophyta species. In late 2004, a French team from the Institute for Research and Development based in Noumea, New Caledonia, conducted a second taxonomic survey. This study recorded algal distributions similar to those found by Womersley and Bailey (1970), but likewise confirmed the existence of at least two additional Rhodophyta species (N'Yeurt and Payri 2007, 2008; N'Yeurt et al. 2007). By combining the algal species found by the two studies referred to above, Payri et al. (2005) confirm that the total number of algal species present in Solomon Islands is 355 (Payri et al. 2005). Interestingly, the studies by Womersley and Bailey (1969, 1970), N'Yeurt and Payri (2007, 2008), and N'Yeurt et al. (2007) mainly focused on macro-algae, and thus excluded micro-algae and cyanobacteria. Numerous species of micro-algae can be assumed to be present in Solomon Islands waters. As Duke et al. (2007) and Albert et al. (2011) confirmed the presence of four toxic species (*Ceratium dens, Brachydinium capitatum, Pyrodinium bahamense var. compressum,* and *Pseudo-Nitzchia* sp.), in all likelihood, Solomon Islands waters are home to more than 355 species of algae.

Mangroves

Mangrove forests are well distributed across Solomon Islands, and occupy a total area of about 65,000 ha (Warren-Rhodes et al. 2011). Pillai and Sirikolo (2001) report 26 species of mangroves from 15 genera and 13 families in Solomon Islands, although these results are based on surveys of only a few locations.[1] In a survey of Choiseul in 2011, M.Q. Sirikolo (personal communication,

[1] Other studies report only 20 species of mangroves in Solomon Islands. The higher number that appears in the text is that of M.Q. Sirikolo (personal communication, 2012), who has extensively analyzed Solomon Islands mangroves.

Senoveva Mauli

A typical mangrove forest in Solomon Islands.

2012) reported yet another species. Thus, Solomon Islands is likely home to 30–32 species of mangroves.

Mangroves serve numerous important ecological functions. In addition to serving as habitats for various species, mangrove forests filter and bind land-based sediments, and thus help recycle nutrients. Mangroves also serve as nurseries for a number of fish species, and numerous species migrate regularly between mangroves and coral reefs. Mangroves also contribute significantly to the livelihood of many Solomon Islanders (Warren-Rhodes et al. 2011) by serving as fishing grounds and a source of firewood, construction materials, and even food, as people in many parts of Malaita and Western consume propagules of *Bruguiera gymnorhiza*.

Coral reef flora and fauna

Solomon Islands has 485 known species of corals from 76 genera, and possibly 9 additional species. The country is thus home to at least 494 species of corals. To place such data in context, this degree of coral diversity is second only to Raja Ampat (Indonesia), where a total of 535 species of corals have been confirmed. Despite this diversity, the number of coral species unique to Solomon Islands is probably quite limited. Veron and Turak (2006) provide a complete list of coral species known to inhabit Solomon Islands waters.

Fish collections have been sourced from Solomon Islands since 1865, with numerous specimens of Solomon Islands fish being found in museums throughout the world (Allen 2006). Based on a comprehensive survey in 2004 (Green et al. 2006), the fish fauna in Solomon Islands total 1,019 species. These belong to 82 families and 348 genera, most of which are associated with coral reefs (Allen 2006). Both habitat type and food availability strongly influence the composition and degree of diversity of the fish communities of particular locations. The greatest degree of fish biodiversity in Solomon Islands is found in 12 sites, many of which are located in the western part of the country. These include Njari (Gizo), Bio (Makira), Three Sister Islands

The Nature Conservancy

Corals in Solomon Islands.

(Makira), Komusupa (Malaita), Emerald (Choiseul), Cormorant (Guadalcanal), Uepi (New Georgia), Minjanga (New Georgia), Roviana (New Georgia), Tua (Shortland Islands), Mbili (New Georgia), and Poro Island (Choiseul) (Allen 2006).

Information on the degree of diversity of marine mollusks in Solomon Islands is scant. The better known species are those of cultural, subsistence, or economic importance. These include six species of giant clams (*Tridacna gigas, T. derasa, T. squamosa, T. crocea, T. maxima,* and *Hippopus hippopus)*; three species of pearl oysters (*Pinctada margaritifera, P. maxima, and Pteria penguin*); two species of trochus *(Trochus niloticus* and *T. pyramis*); and three species of green snails (*Turbo marmoratus*, *T. setosus, and T. argyrostomus*). As the most conspicuous mollusks in Solomon Islands also occur elsewhere, they are easy to identify. At this writing, Solomon Islands has no known endemic species of mollusks.

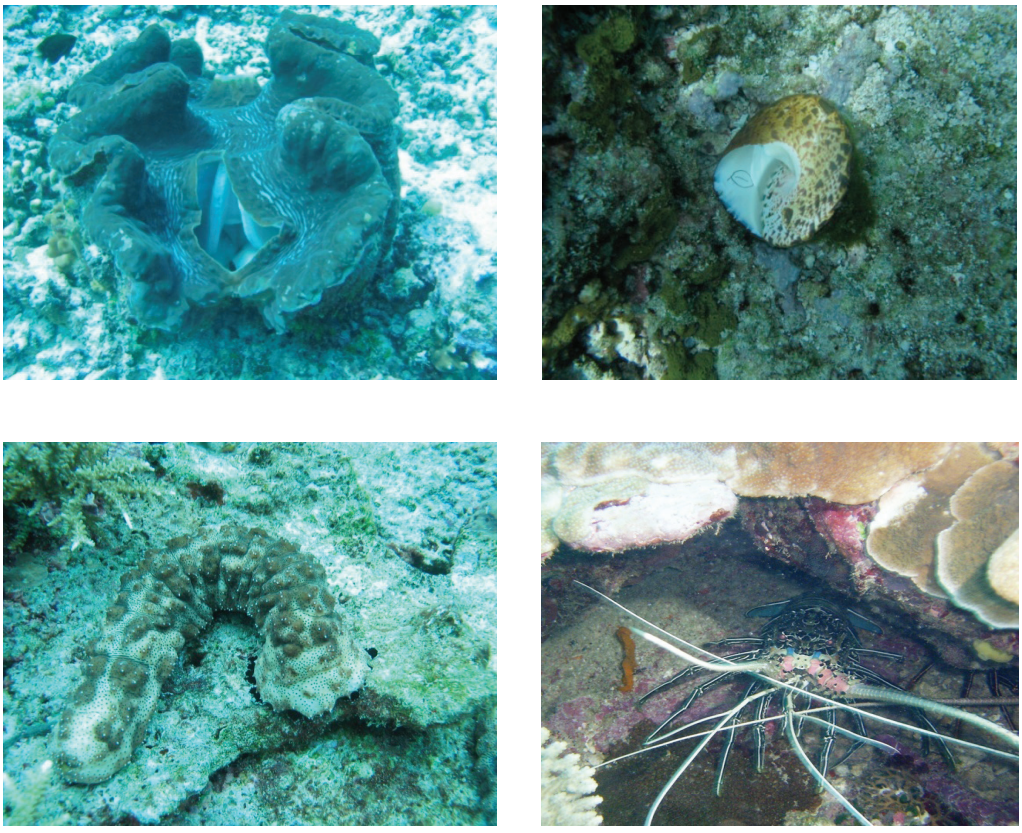
The number of echinoderm species that inhabit Solomon Islands water is also unknown. However, some species such as sea cucumbers are well known because of their economic importance. In all, 19 sea cucumber species have been confirmed in Solomon Islands waters. Historically, sea cucumbers were an important commodity, as they were processed and exported to Asian markets as a delicacy until the Solomon Islands sea cucumber fishery was closed. As the prices they fetch are only rivaled by the price of shark fins, up until the fishery was closed, sea cucumbers were an important source of cash income for rural coastal inhabitants. Unfortunately, the lucrative price they attracted contributed heavily to their demise, as their rate of extraction in most locations remained above sustainable levels. Such unsustainable extraction rates were confirmed by Ramohia (2006) in this study, including a benthic survey of macroinvertebrates. Of the 19 recorded species of sea cucumbers known to inhabit Solomon Islands waters, only 17 were observed. Further, the species that command particularly high prices were found only in deep locations (Ramohia 2006).

Most sponges in Solomon Islands are those commonly found in the Indo-Pacific region (Payri et al. 2005). Early studies such as Berquist et al. (1971) recorded 30 species. The most recent collections of sponges were made by a French team in 2004 (Payri et al. 2005), and by the

University of the South Pacific and Queensland Museum of Natural History joint expedition in 2005. The resulting collections were deposited at the Queensland Museum of Natural History in Brisbane, Australia. The status of the specimens is unknown. Hence, the degree of biodiversity of sponges in Solomon Islands cannot be confirmed. Of late, there has been major interest in sponges on the part of persons and organizations involved in bioprospecting, with the most recent collections being made by the Institute of Applied Science of the University of the South Pacific in 2012.

Cetaceans, sirenian, and reptiles

Based on various reports (Shimada and Pastene 1995, Goto et al. 1997, Leary and Pita 2000, Shimada and Miyashita 2001, Kahn 2006), eight species of whales currently inhabit Solomon Islands waters (*Balaenoptera edeni, Globeicephala macrorhynchus, Peponocephala electra, Orcinus orca, Mesoplodon sp., Balaenoptera sp., Physeter macrocephalus,* and *Megaptera novaeangliae*). Leary and Pita (2000) report nine species of dolphins, this number being confirmed by numerous reports. However, subsequent sightings have confirmed only six species (*Stenella longirostris*, *Stenella attenuata, Tursiops truncatus*, *Tursiops aduncus*, *Grampus griseus,* and *Steno bredanensis*). Five species of turtles (*Eretmochelys imbricata*, *Chelonia mydas*,



Peter Ramohia

(*From top left to right*): Giant clam (*Tridacna gigas*) in Arnavon Islands Reefs; and trochus, sea cucumber species, and lobster (*Panulirus* sp.) that are common in Solomon Islands waters.

Dermochelys coriacea, *Lepidochelys olivacea*, and *Caretta caretta*) and one species of crocodile (*Crocodyllus porosus*) are known to inhabit the country. Only one sirenian (*Dugong dugon*) is present in Solomon Islands.

No comprehensive compilation of the information regarding the degree of biodiversity present in Solomon Islands is currently available, as this information is reported in a wide range of journals, reports, and articles. Nor does an up-to-date list of studies of marine biodiversity in Solomon Islands waters exist. This is even true for economically important species such as sharks. While widely exploited in Solomon Islands for their fins, the number of shark species present in Solomon Islands waters is unknown. As a result, some of these species may become extinct long before their existence in the country is even confirmed.

Governance

Policy and Legislation

Policies for protecting inshore marine habitats (coral reefs, seagrass beds, and mangroves) are embodied in the general government policies of successive governments that address marine resources. Examples include the *Coalition for National Unity* 2008 (Office of the Prime Minister, Solomon Islands Government 2008) and *The National Coalition for Reform and Advancement (NCRA) Government Policy Statement* (Office of the Prime Minister, Solomon Islands Government 2010). Other documents such as the *National Biodiversity and Strategic Action Plan* (Pauku and Lapo 2009) lay out strategies for protecting marine resources and coral reefs in particular. Likewise, a number of policy documents state overall national strategies for (i) managing inshore fisheries, (ii) environmental conservation, (iii) adaptation to climate change, and (iv) application of the ecosystem approach to resource management. These latter policy documents include the following:

(i) National Strategy for the Management of Inshore Fisheries and Marine Resources (Ministry of Fisheries and Marine Resources [MFMR] 2010);
(ii) Solomon Islands Coral Triangle National Plan of Action (Ministry of Environment, Conservation and Meteorology [MECM] and MFMR 2010); and
(iii) National Adaptation Programme of Action (MECM 2008).

The Government of Solomon Islands is also a party to several regional and international agreements that address the protection, sustainable use, and responsible management of coral reefs and marine resources (Table 1).

Acts of the Solomon Islands National Parliament that directly provide for marine environmental protection, sustainable use, and management of marine resources include the following:

(i) The Fisheries Act 1998, which provides for the protection, sustainable use, conservation, and management of fisheries resources in general;
(ii) The Wildlife Protection and Management Act 1998, which was enacted to comply with the country's obligations under the United Nations Convention on Biological Diversity, and the trade (both export and import) in wildlife fauna and flora in particular;
(iii) The Shipping Act 1998, which protects the marine environment, prevents pollution from marine vessels, and implements various International Maritime Organization conventions (e.g., the Marine Pollution Convention);
(iv) The Environment Act 1998, which establishes an integrated system for controlling development, performing environmental impact assessments, and pollution control; and

(v) The Protected Areas Act 2010, which provides for the declaration and management of protected areas in cases where special measures are required for conserving biological diversity, and regulating the latter as well as bioprospecting research.

If the country's marine environment is to be protected, and its resources managed in a sustainable manner, then the national legislation referred to above must be supported by appropriate provincial ordinances. The Provincial Government Act 1997 lays the foundation for such protection by declaring territorial boundaries for each province that extend three nautical miles out to sea from the low waterline of each island, atoll, and reef. However, a significant portion of the administrative jurisdiction of each province's coastal and marine environment is under customary marine tenure (CMT). As a result, all provinces should enact ordinances that support both national and customary management frameworks. In this regard, the CTI and partner NGOs such as The Nature Conservancy, the WorldFish Center, and the Worldwide Fund for Nature (WWF), formerly the World Wildlife Fund, have recently assisted some provinces in formulating fisheries ordinances that provide for the management and sustainable use of fisheries and associated marine ecosystems.

The current status of these provincial ordinances is as follows: Western Province already has a provincial fisheries ordinance and a natural resource management ordinance. Both Choiseul island and Central Islands provinces have draft provincial fisheries ordinances. Choiseul province also has a resource management ordinance. While other provinces have environment-related provincial ordinances, some lack provisions for protecting biodiversity and integrating customary resource owners in resource management (McDonald 2007). As a step forward in establishing such provincial ordinances, at the first-ever Premiers Environment Round Table in 2011, the premiers of all provinces committed to review or formulate environment-related ordinances, and to mainstream environment and climate change issues into their respective provincial development plans.

Compliance

Compliance with obligations under international treaties and conventions acceded to or ratified by Solomon Islands

Solomon Islands has enacted legislation to comply with its obligations under the environmental conventions it has ratified. In this regard, a series of national capacity self-assessment studies funded by the Global Environment Facility have identified significant gaps in the existing legislation (McDonald and Lam 2006, McIntyre 2006, Siho 2006, Thomas 2006, Thomas et al. 2006). These gaps are summarized below.

(i) Lack of government capacity (both in terms of financial and human resources) for addressing environmental issues, enforcing legislation, and implementing local-level actions and initiatives for ensuring sustainable use of the marine resource;
(ii) Absence of "government" in the most general sense in the communities, the level at which most unsustainable marine resource use patterns prevail. In fact, most community resource management and conservation initiatives have been driven primarily by NGOs and churches.

Table 1 **Multilateral Marine Resource Agreements to which Solomon Islands Is Signatory**

Convention/ Instrument	Status	Purpose	Current Title of Agency Responsible for Implementation
South Pacific Regional Multilateral Agreements			
Waigani Convention	Ratified 10 July 1998	Bans the importation of hazardous and radioactive waste, and controls transboundary movement and management of hazardous waste within the South Pacific region	MECDM
Pollution Protocol for Dumping	Ratified 9 October 1989	Prevents pollution of the South Pacific region by dumping	Marine Division and MECDM
Pollution Protocol for Emergencies	Ratified 9 October 1989	Promotes cooperation in combating pollution emergencies in the South Pacific region	Marine Division and MECDM
Natural Resources and Environment of the South Pacific (SPREP Convention)	Ratified 9 October 1989	Protects natural resources and environment through management and development of the marine and coastal environment in the South Pacific region	MECDM
Chemical Waste and Marine Pollution			
Liability for Oil Pollution Damage	Ratified	Imposes strict liability on a ship owner for pollution damage to a coastal state within a certain amount	Marine Division
Marine Pollution Convention (London)	Ratified	Prevents marine pollution by dumping of waste and other matter	MECDM and Ministry of Foreign Affairs
Biodiversity			
United Nations Convention on Biological Diversity	Ratified 10 March 1995	Conserves biological diversity through sustainable use of its components and fair and equitable sharing of the benefits arising from utilizing genetic resources	MECDM
United Nations Convention to Combat Desertification (UNCCD)	Acceded to 16 April 1999	Combats desertification and mitigates the effects of drought in countries experiencing drought or desertification	Agriculture Division and MECDM

continued on next page

Table 1, *continued*

Convention/ Instrument	Status	Purpose	Current Title of Agency Responsible for Implementation
Cartagena Protocol on Biosafety	Acceded to 26 October 2004	Protects human health and the environment from possible adverse effects of products of modern biotechnology, living modified organisms in particular, while maximizing their benefits	MECDM
Convention on International Trade in Endangered Species	Acceded to 26 March 2007	Regulates and restricts trade in specimens of endangered wild animals and plants through a certification system for imports and exports	MECDM
United Nations Convention on the Law of the Sea	Ratified 23 June 1997	Defines the rights and responsibilities of nations regarding their use of the world's oceans, establishing guidelines for businesses, and management of the environment and marine natural resources	MFMR, Ministry of Foreign Affairs, and Attorney General's Chamber
World Heritage Convention	Acceded to 10 June 1992	Protects sites of outstanding universal value such as East Rennell, which is a World Heritage site	National Museum and MECDM
Climate			
Kyoto Protocol	Ratified 13 March 2003	Reduces greenhouse gases, especially carbon dioxide, by the 39 industrial and/or developed countries by an average of 5.2% by 2012	MECDM
United Nations Framework Convention on Climate Change	Ratified 28 December 1994	Formulates an overall framework for intergovernmental efforts in addressing challenges posed by climate change	MECDM
Montreal Protocol	Acceded to 17 June 1993	Phases out substances that deplete the ozone layer according to a fixed schedule	MECDM
Ozone Layer Convention (Vienna)	Acceded to 17 June 1993	Protects the ozone layer through intergovernmental cooperation on research, systematic observation of the ozone layer, and monitoring of chlorofluorocarbon (CFC) production.	MECDM and Energy Division

MECDM = Ministry of Environment, Climate Change, Disaster Management and Meteorology; MFMR = Ministry of Fisheries and Marine Resources; SPREP = Secretariat of the Pacific Regional Environmental Programme.

Source: Updated from Pacific Horizon Consultancy Group. 2008.

(iii) Lack of legislation required for sustainable management of the marine resource, or in cases where such legislation exists, inadequate legislation for achieving this objective (McDonald and Lam 2006).

The above notwithstanding, some of these shortcomings have been addressed in recent years. For example, the Protected Areas Act 2010 was enacted as a response to concerns raised by McDonald and Lam (2006) that appropriate national legislation for establishing protected areas and conserving biodiversity was absent, and that the Wildlife Management and Protection Act 1998 lacked provisions for *in-situ* protection of endangered species. Further, the Fisheries Act 1998 is currently being reviewed (under The Fisheries Bill 2010) to address fisheries-related issues. For example, changes to the Fisheries Bill 2010 currently being considered include allowing local communities to manage marine resources within their own jurisdictions, and adopting the ecosystems approach to fisheries management (MFMR 2010).

Local compliance

While the laws, regulations, and conservation initiatives by government, NGOs, and community-based organizations described above are a welcome development, compliance at the local level remains a major challenge. For example, dynamite fishing is commonly practiced in Nggela, Malaita, and Guadalcana, despite the fact that local residents there are well aware that it is illegal under national law. Both hunting and consumption of turtles remain common practices in many parts of the country, despite the fact that fisheries regulations prohibit these practices. Similarly, the sea cucumber harvest closure currently in effect is flouted by resident foreign nationals who purchase illegally harvested sea cucumbers and export them (Inifiri and Marau 2012, Osifelo 2012). Even compliance with regulations put into place by community-based MPAs remains a challenge (R. Sulu, personal observations in Nggela, 2012). Local compliance even remains a challenge in Arnavon Marine Conservation Area, which is the best managed conservation area in Solomon Islands in that it employs full-time rangers (J. Pita, personal communication, 2012).

In sum, for a number of reasons, compliance with conservation and marine resource protection and management laws, regulations, and initiatives will remain a challenge for some time. These reasons include (i) weak legal status; (ii) lack of enforcement; and (iii) a need at the community level to generate income to meet daily subsistence requirements, personal needs, and social obligations. Ignorance of the long-term consequences of destruction of the marine resource as well as the rationale for environmental regulations may also be contributing factors. In this regard, improving awareness of both on the part of resource users may lead to informed compliance (Foale 2006).

Socioeconomic Characteristics

Demography

In 1999–2011, the country's population grew from 409,000 to about 516,000, or at an annual average rate of 2.3% (Solomon Islands National Statistics Office 2011). This represents a significant reduction in the population growth rate, which in 1999 was 3.4%. However, as a result of rural–urban migration, the difference between the annual population growth rate in urban (4.7%) and rural areas (1.8%) is significant.

Further, the geographic distribution of the country's population across provinces remains uneven. For example, in 2009, Malaita had a population of 137,596; Guadalcanal, 93,613; Western Province, 76,649; Honiara, 64,609; Makira, 40,419; Choiseul, 26,372; Isabel, 26,158; Central Province, 26,051; Temotu, 21,362; and Rennell, 3,041. As immigration is not a major factor in population growth in Solomon Islands, virtually the entire increase in the national population reported above resulted from natural increase.

While the mean age at first marriage is 25.5 years, that for males (27.1 years) differs significantly from that for females (23.3 years). Further, Solomon Islands has a relatively young population, with persons aged 25 years or below accounting for more than half of the overall population. As for the gender ratio, there are 105 males for every 100 females (Figure 1).

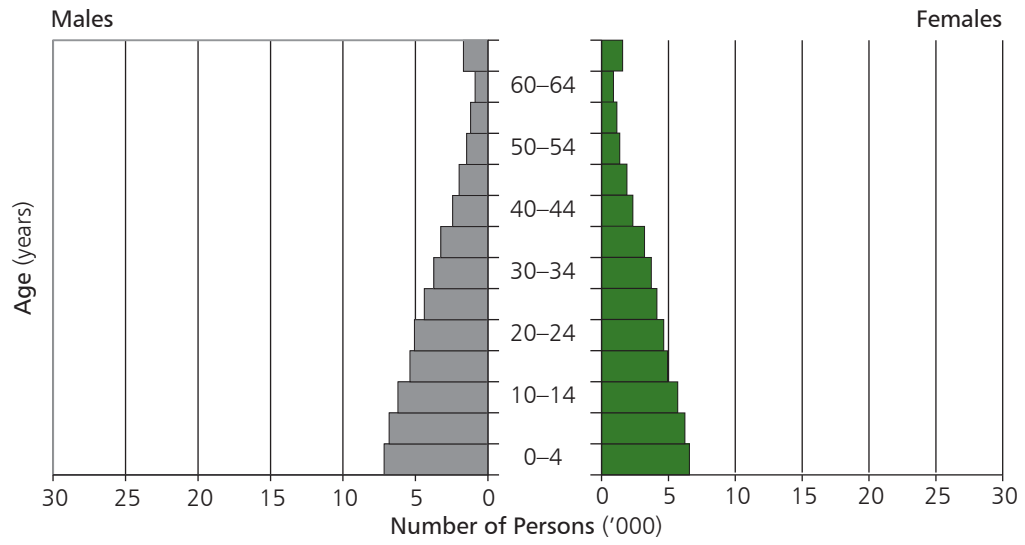
The 2011 population density of 17 people per square kilometers (km^2) represents a significant increase from its 1999 level, which was 13 per km^2. Average household size is 5.5 individuals. Only 15.7% of the population is classified as being employed, while the remainder is classified as either subsistence or unpaid workers. About 80% of the overall population lives in rural areas (Table 2). The majority of communities are located along the coastline. Most communities located further inland have access to the sea.

Traditional Management Systems

The major traditional marine resource management mechanisms include (i) control of access through customary marine tenure (CMT) arrangements, (ii) articulation of traditional ecological knowledge (TEK) for resource management,[2] (iii) prohibition of access to and exploitation of resources within culturally significant geographic areas, and (iv) prohibition of consumption

[2] Also referred to as indigenous ecological knowledge.

Figure 1 **Age Composition of the Solomon Islands Population, 2011**



Source: Solomon Islands National Statistics Office. 2011.

Table 2 **Demographic Parameters in Urban and Rural Areas of Solomon Islands**

	Urban	Rural
Population	101,798	414,072
Average household size	6.5	5.3
Median age	22.3	18.9
Ratio of males to females	111:100	104:100
Ratio of children to women	439:100	658:100

Source: Solomon Islands National Statistics Office. 2011.

of certain species. CMT regimes in Solomon Islands are inextricably linked with the wider social and cultural contexts from which they emerge (Hviding 1994). Hence, they are tightly embedded in the society's TEK, traditional beliefs, access control and prohibitions, social and/or governance structure, and other customary practices (Hviding 1994, Ruddle 1994, Foale 1998b, Berkes et al. 2000, Hickey 2006).

The CMT system, which is recognized by the Solomon Islands National Constitution of 1978, is the major form of traditional property ownership and control. More than 90% of inshore coastal areas, islands, and islets are owned and managed under the CMT system. Under this system, particular groups of people (e.g., family units, clans, or tribes) have informal or formal rights to coastal areas, as well as historical rights to access and use marine resources. In principle, these rights are exclusionary, transferable, and enforceable, either on a conditional or permanent basis (Ruddle 1996, Aswani 2005). Although CMT is the major system of marine property ownership, studies of the CMT have been conducted in only a few locations in Solomon Islands. These include (i) Lau lagoon in Malaita (Akimichi 1978, 1991); (ii) Marovo lagoon in New Georgia (Hviding and Baines 1992, 1994; Ruddle et al. 1992; Hviding 1993, 1996, 1998; Lidimani 2006); and

(iii) Roviana and Vonavona lagoons in New Georgia (Aswani 1997a, 1997b, 1998a, 1998b, 1999, 2002, 2005; Hamilton 2003; Aswani and Hamilton 2004; Aswani and Lauer 2006; Aswani et al. 2007; Aswani and Sabetian 2009), and Nggela (Foale and Day 1997; Foale 1998a, 1998b, 1998c, 1999, 2002; Foale and Macintyre 2000; Sulu 2010).

In Lau lagoon, CMT rights within clearly defined boundaries inshore are owned by collective groups. While primary rights to the use of marine resources are inherited in a patrilineal way, secondary and usufruct rights exist, the latter allowing limited use or profit from these resources, so long as the resources in question are neither damaged nor destroyed. Shallow areas that are limited in resources, as well as the deep seas in Lau, are subject to de facto open-access use by the community, and are usually reserved for those who have no marine tenure rights. Akimichi (1991) described the Lau CMT system as being tightly interwoven with the local traditional economy and local ecological knowledge. Typically, the most commonly used measures for managing fisheries include closure of designated areas for reasons of traditional beliefs, and closure of fishing areas for several months following the death of a chief or a traditional religious priest. However, advent of the market economy has transformed the Lau CMT system. In particular, it has resulted in the weakening of the closure system, and significantly increasing harvest rates, which in turn have resulted in declines in the productivity of marine resources in Lau lagoon (Akimichi 1991).

Ownership of *puava* (marine areas) in Marovo lagoon is through collective groups called *butubutu,* the ownership of these areas being passed through ambilineal cognatic descent. While *puava* is a geographical space that has clearly defined boundaries, *butubutu* is fluid in nature, as marriages and interrelationships define and redefine social boundaries, which ultimately affect rights and access to *puava*. Life in Marovo is tightly interwoven with the sea, as indicated by Marovo fishers' fishing practices and their extensive knowledge of marine species and behavior (Hviding 1996, Johannes and Hviding 2001). The Marovo CMT system employs several fisheries management methods, including closures similar to modern methods of fisheries management (Hviding 1994). Though deeply rooted in the past, the Marovo CMT system is flexible, in that it has adapted to changing ecological, social, and economic circumstances (Hviding 1993, 1998). Hviding (1998) provides examples of successful adaptation of the CMT system to economic and development pressures (e.g., mining, logging, and industrial fishing).

The CMT system in Roviana and Vonavona lagoons is also based on collective ownership of marine tenure rights that are inherited through ambilineal cognatic descent (Aswani 1999).[3] Primary, secondary, and usufruct rights all exist within this system. Endogenous factors historical in nature have contributed to subtle local regional differences in the CMT regimes in Roviana and Vonavona.[4] Exogenous factors that aid endogenous factors are changes in consumption (i.e., shift from a subsistence economy to reliance on cash for purchasing imported food, (e.g., rice, flour, and tinned foods) and demography (i.e., differences in population and ethnic composition resulting from intermarriage among people from different islands and countries) (Aswani 2002). Three types of CMT currently exist in Roviana and Vonavona as a result of endogenous historical

[3] Based on tribes.

[4] Includes local regional settlement patterns (i.e., historical movement of people within the local region resulting from marriage, political coercion, or other social factors) and local historical processes of political expansion and contraction resulting from internal political friction within a society, and intertribal warfare and conquests (Aswani 1999).

processes and exogenous factors. These are the territorial-enclosed entitlement regime, the mosaic entitlement regime, and the transitory estates regime (Aswani 1999).

Subtle regional differences in the three CMT regimes described above impact their role in inshore fisheries management (Aswani 1999, 2005). The territorial-enclosed entitlement regime is the most effective regime for inshore fisheries management (Aswani 1997b). Territorial disputes in the mosaic-entitlement regime and in the transitory-estates regime cause social instability that subsequently results in environmental degradation (Aswani 1997b, 1999). As in other areas, the culture in Roviana and Vonavona is tightly interwoven with the sea, and fishers possess extensive indigenous ecological knowledge of the marine environment and marine species, both these being useful in fisheries management (Aswani and Hamilton 2004, Aswani 2005, Aswani and Lauer 2006, Aswani et al. 2007).

Marine property ownership in Nggela is also based on collective ownership passed through matrilineal inheritance. The social structure is based on four clans, each of which contains seven subclans (Foale 1998b, Sulu 2010). The major corporate entity through which marine resources are accessed and used is one of the 28 subclans. The *huihui* process provides an alternative means of acquiring land and marine tenure rights through patrilineal inheritance, as a gift, or through other significant transaction processes.[5] In a *huihui*, those acquiring rights prepare food, pigs, and traditional money (nowadays cash and modern goods as well), and present these to those who own the land and marine tenure rights. On receipt of the goods during a public ceremony that must be witnessed by chiefs, the primary owners relinquish their rights. Land and marine tenure rights acquired through *huihui* are valid only through three patriline generations (three generations of men). Unless another *huihui* is done at this stage, land and marine tenure rights revert to the original subclan and clan. After *huihui*, land and/or marine ownership rights can then be transferred through matrilineal inheritance. Clan and subclan memberships are fixed through birth. There are no social processes for changing the composition of clan or subclan membership (Foale 1998b, Sulu 2010). Marine resource management under this CMT system includes serial prohibitions and control of access to the resources concerned (Foale 1998b).

CMT studies in Solomon Islands collectively show that the major methods of marine resource management include limited entry, closed seasons, closed areas, size limits, species prohibitions, and gear restrictions, all of these being methods also reported to be practiced elsewhere in the South Pacific (Johannes 1981, Cinner and Aswani 2007). Although the general principles of CMT are the same across Solomon Islands where it has been studied, the manner in which CMT is implemented varies across locations, and even within particular locations (Aswani 1999). Each CMT is unique, as it is embedded in the particular historical, socioeconomic, and political context to which it relates. As a result, applications of CMT to fisheries management and responses to such applications vary, depending on the location concerned.

The role of TEK in marine resource management is a contentious matter. Polunin (1984) and Aswani (1998a) argue that its goal is usually maximizing the output of particular fisheries, and thus could potentially contribute to resource depletion. For example, Hamilton (2003) reports a case in which indigenous knowledge contributed to the depletion of the bumphead parrotfish

[5] The closest English equivalent being "unhook" or "unlock."

(*Bolbometopon muricatum*) by Roviana fishers. Similarly, Foale (2006) reports that Nggela fishers associated the subtle increases in *trochus* numbers when the *trochus* spawn as being good times for harvesting. The above notwithstanding, when appropriately used in conjunction with conventional scientific data, TEK can contribute to achieving sustainable use of marine resources (Hamilton and Walter 1999). Traditional knowledge regarding resource management is particularly important in circumstances in which government fisheries departments are ill-equipped to carry out fisheries research, or to generate the information required for achieving sustainable management of marine resources (Johannes 1978, 1998).

For example, Hamilton et al. (2005) relied on indigenous ecological knowledge to identify grouper spawning aggregation sites, aggregation times, and some aspects of the biological relationships of grouper spawning aggregation in Solomon Islands. This information could be useful for fisheries management purposes, given that it is integrated with modern scientific knowledge. This information was mainly generated through interviews, which were more cost-effective than modern fisheries surveys. Aswani and Hamilton (2004) report that studying indigenous ecological knowledge of bumphead parrotfish

(i) provided important information on the historical changes in abundance of the species and their need for protection,
(ii) facilitated understanding of the manner in which various habitats impact the size distribution of species,
(iii) helped identify locations and habitats that require protection, and
(iv) helped comprehend how lunar periodicity affects the behavior and catch rates of the species concerned.

Aswani and Lauer (2006) used indigenous ecological knowledge to design and implement appropriate resource management strategies that were both cost-effective and participatory.

Although traditional management systems offer advantages for inshore fisheries management in Solomon Islands, over the past 30 years, modernization and socioeconomic change have contributed to their ineffectiveness in some instances. Some significant factors in this regard include (i) waning respect for traditional leadership and authority (Wairiu and Tabo 2003); (ii) the influence of markets and resulting commoditization of resources (Foale 1998a, Hamilton 2003); (iii) changing consumption and demographic patterns (Aswani 2002); (iv) adoption of new religious beliefs and the consequent demise of traditional belief systems (Hviding 1996, Lidimani 2006); and (v) use of modern, more efficient fishing gear (Hamilton 2003). In some cases, the impact of these factors has been so overwhelming as to make CMT unable to arrest the decline of some species located in sites adjacent to urban areas. These include (i) some finfish species (Sabetian and Foale 2006, Aswani and Sabetian 2009, Brewer et al. 2009); (ii) *trochus* (Foale 1998a); (iii) green snail *Turbo marmoratus* (Green et al. 2006), which is exported and used to manufacture buttons and jewelry; (iv) *Holothuria* species harvested for the bêche-de-mer trade (Kinch 2004); and (v) *Tridacna* species whose adductor muscles, as well as its shells, are a culinary delicacy in Asia, and which are harvested for the curio trade (Sulu et al. 2000).

Despite the inability of CMT to achieve sustainable inshore fisheries management, modern-day measures have not generally replaced these traditional forms of marine resource management (Hviding 1998). As a result, CMT continues to function as a sociopolitical link between local communities and their respective marine environments. They likewise retain a key role in coastal

resource development initiatives in Solomon Islands (Hviding 1998). As a result of their dynamic and flexible nature, in some cases, CMT systems have adapted to modern-day pressures by undergoing organizational innovation and reinforcement. Thus, while certainly not a panacea for unsustainable marine resource extraction rates, they remain central to sustainable marine resource management in Solomon Islands (Foale 1998b). Maximizing their beneficial role in achieving sustainable marine resource management will require (i) increased understanding of how external factors (e.g., markets, new laws and legal systems, new forms of religion, and new governance systems) impact CMT; and (ii) how differences between CMT and modern fisheries management methods can be used to create adaptive management systems that meet the requirements of local communities (Cinner and Aswani 2007).

Achieving sustainable marine resource management by integrating the CMT system with the modern legal system is no doubt possible, as this has been previously achieved. Indeed, legal provisions in the country's national legislation allow such integration.[6] For example, the Western Province Natural Resource Management Ordinance and the legal instruments associated with the establishment of the Arnavon Community Marine Conservation Area (ACMCA) provide for a formulation of community bylaws for resource management. These bylaws are enforceable in court. The fisheries ordinance of Central Islands Province, which was being drafted as of February 2012, allows formal powers to be used to enforce customary marine resource management systems. While legal provisions allow such integration, the most formidable challenge to achieving sustainable marine resource management through this means is that of achieving compliance through mitigation of incentives for unsustainable extraction rates that are driven by the cash economy. According to a conservation officer at ACMCA (John Pita, personal communication, 2012), a major impetus for compliance at ACMCA was the provision of alternative means of generating income through the establishment of seaweed farming in the Wagina community (Kronen et al. 2010b), which relies solely on marine resources for both its livelihood and income generation.

Gender Issues

Weeratunge et al. (2011) describes gender participation in Solomon Islands fisheries as being bounded to a certain extent by space. Men fish on the reefs and in the offshore zones, while women and children fish in the inshore environment, which includes reefs adjacent to villages, lagoons, and mangrove areas. To some extent, this spatially defined gender participation determines the choice of fishing methods used. Men predominantly dive and fish with lines, while women mainly glean for invertebrates, fish for inshore reef species, harvest mangrove propagules in locations where these are consumed as food, and collect seaweed. Both men and women participate in aquaculture activities (e.g., growing giant clams, corals, and seaweed) (Kronen et al. 2010b, Weeratunge et al. 2011). Women comprise the majority of the labor force in the industrial fishing subsector (e.g., fish factories and canneries) (Tuara-Demke 2006). In the household own-production subsector, women play an important role in postharvest processing, value-added processing, and in the sale or marketing of fisheries products (Sulu, personal observation, 2012).

[6] For a general overview, see Kabui (1997), Lidimani (2006), and McDonald (2007).

Women theoretically play an important role in communities where the land ownership inheritance system is matrilineal. However, in reality, men (e.g., sons, brothers, or husbands of inheritors) decide on matters pertaining to land, with women usually having little voice in such matters (Japan International Cooperation Agency [JICA] 2010, Weeratunge et al. 2011). Others (A. Schwarz, personal communication, 2012) argue that women influence men's decisions in subtle, less obvious ways, and that in some cases women are able to firmly assert their views. According to Weeratunge et al. (2011), gender relations and disparities play a significant role in fisheries-related rural livelihoods, access to marine and coastal resources, and decision making as regards resource use. Nevertheless, women are reported to play a significant role in managing fisheries resources in environments where women themselves exploit such resources, such as in the case of shell beds in mangrove areas (Aswani and Weiant 2004).

Payment for Ecosystem Services

All ecosystems such as coral reefs and mangrove forests provide various valuable services to people. Until recently, these services were assumed to be so abundant that no rate of their exploitation would degrade the ability of the ecosystem to provide these services. However, large-scale ecosystem degradation has made it obvious that the rate at which ecosystems can provide such services is finite. This has lately underscored the fact that, as with virtually all other goods, ecosystem services have scarcity value that can be priced in monetary terms.

In the case of human-made goods, markets naturally develop that put a price on this scarcity value. 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 the finite stream of services that ecosystems provide can be maintained in perpetuity.

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. Ultimately, the higher the price of a resource, the more sparingly it will be used. Thus, by assigning a monetary value to the services that ecosystems provide, PES schemes ensure that these services 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.

PES schemes provide monetary compensation to the custodians of the ecosystem in question (e.g., a community with ownership rights over an adjacent coral reef or mangrove forest). This monetary compensation provides an incentive for the custodians to maintain a certain level and quality of ecosystem services, thus ensuring their sustainability.

Because PES schemes are relatively new to Solomon Islands, none have yet been implemented. In fact, only one study has outlined the details of a proposed PES scheme, the purpose of which was to simultaneously mitigate rural poverty and address climate change (Warren-Rhodes et al. 2011). This study focused on three coastal communities: Buri, Ranongga, Western Province; Boeboe, Choiseul Province; and Talakali, Langalanga lagoon, Malaita Province.

The study concluded that the mangrove ecosystems in these three communities provide ecosystems goods and services (e.g., fish nursery habitats), as well as direct and indirect

subsistence and monetary benefits to local residents. However, since these mangroves have been overexploited, their ability to provide such ecosystems services is under threat. They thus need to be protected.

These mangroves could be protected by implementing a mangrove replanting and conservation initiative that is linked with a carbon credit scheme. While this initiative would likewise provide income to members of the communities concerned, to be successful over the long run, a number of challenges would have to be addressed when formulating the mangrove replanting and conservation initiative. These include the need to (i) integrate subsistence options into the initiative, (ii) take account of the complex and variable nature of land tenure systems in the communities in question, and (iii) devise a means of sharing the initiative's benefits that is both equitable and transparent. Interestingly, the study also concluded that mangrove ecosystem surveys are useful tools for raising community awareness and obtaining input from local residents before designing PES systems.

While the study referred to above focused on mangrove forests, the issues it raised are general in nature, and thus may also apply to other ecosystems where PES schemes might be viable.

Other ongoing PES-related studies are two studies (one on coral valuation and one as a regional technical assistance) funded by ADB as part of the CTI activities in Solomon Islands.

Capture Fisheries

Statistics from the Food and Agriculture Organization (FAO) show total fisheries landing in the Solomon Islands ranging between 24,000 and 40,000 tons/year during the decade 2000–2009. A reconstruction of Solomon Island fisheries that incorporates additional information, including the domestic commercial tuna industry and artisanal and subsistence fisheries (Doyle et al. 2012), estimated total catches of 32,000–50,000 tons/year, generally 10,000–12,000 tons/year higher than FAO data. Much of the discrepancy has been due to unreported subsistence catches, as well as tuna baitfish, by-catch in the tuna fishery, shark catches, and export of invertebrates such as trochus, sea cucumbers, and pearl shell.

Subsistence fisheries

Most rural areas of Solomon Islands have a subsistence economy based on fishing and gardening, in which coastal fisheries play a central role (Boso et al. 2009, Paul et al. 2009, Boso and Schwarz 2010). However, no figures regarding the extent of fishing activity—much less, subsistence fishing activity—in Solomon Islands are available. The best estimates available suggest that nearly half of all women and 90% of all men fish (Weeratunge et al. 2011). Further, in most rural households, at least one household member is involved in fishing (Weeratunge et al. 2011). For the most part, wooden dugout canoes and motor-powered fiberglass boats are used, along with simple fishing gear such as handlines, nets, or spears.

Surplus fish and garden produce are often either shared with other community members or sold for cash, which is then exchanged for household necessities (Boso et al. 2009, Boso and Schwarz 2010). Depending on household requirements, most of the fish catch—usually the best—is

sold either fresh or cooked at local markets. Other means of earning cash income are limited, due to lack of transport and processing infrastructure and absence of accessible microcredit facilities in rural areas. Based on earlier reports and subsequent population increase, Gillett (2009) estimates that the country's total coastal subsistence catch in 2006 was 15,000 tons, with a value of $11 million. The reconstruction of Solomon Islands fisheries catches (Doyle et al. 2012) estimated that nearly 16,000 tons of subsistence finfish and invertebrate catches were consumed domestically in 2009.

Small-scale fisheries

The quantity of fish sold by most rural fishers depends on their household requirements, any excess above this is generally being sold locally. However, other fishers sell their fish in urban areas. While Honiara is generally the urban market of choice, others sell in provincial urban centers such as Auki (Malaita), Gizo, Kirakira, Munda, and Tulagi. Still other fishers who live in communities near PNG sell in urban markets even as distant as Bougainville (Boso et al. 2009). The Solomon Islands National Statistical Office estimates that in 2006, 16% of households involved in self-employed commercial activity sold fish and other types of seafood (Solomon Islands National Statistics Office 2006). This report refers to the sale of such produce and the near-shore fishing activity associated with it as "small-scale fisheries".

Brewer (2011) describes a wide-ranging fish value chain that includes fishers who sell their catch (i) directly at market, (ii) directly to value-added processors, (iii) to value-added processors through middlemen, and (iv) directly to private fish centers. In the mid- and late 1990s, the MFMR established rural fisheries centers (RFCs) in nine provinces with the assistance of various donor agencies. These RFCs aim to stimulate development of the country's rural economy by expanding income-generating activities associated with local fisheries. These RFCs both provide ice to fishers and purchase their catch, which is then sold elsewhere, mostly in the Honiara market or directly to hotels and restaurants in the capital. Attempts at aggregating the catches purchased from the RFCs for export to Australia performed in 2007 resulted in only 11 of the 30 RFCs being reasonably successful in this regard (Lindley 2007). The major problems encountered included (i) lack of maintenance of RFC facilities; (ii) a weak transport chain linking the RFCs with Honiara; and (ii) prohibitive transport costs in cases in which fish were transported from distant provinces, particularly in the face of abundant fish catches originating in Nggela, Russell Islands, and even Honiara itself. That said, several RFCs are now being repaired with donor support (G. Carlos, personal communication, 2011).

However, in the local markets, these RCFs are important sources of cash income for fishers, since their alternative means of earning a livelihood are limited. Since many of these fishers had previously relied on cash income generated from the sale of sea cucumber that they had collected, closure of the sea cucumber fishery in 2010 further limited the number of livelihood strategies available to them. While the total value of the fish catch that passes through these RFCs and other private fishing centers has not been formally assessed, Lindley (2007) estimates said value at SI$5 million (Lindley 2007). Similarly, Brewer (2011) estimates the total annual value of inshore finfish fisheries at SI$2.6 million (Brewer 2011).

Gillett (2009) estimates the value of the total annual coastal catch by "commercial" (i.e., non-subsistence) fisheries during 2005–2007 as composed of (i) local sales for domestic

consumption of about 1,500 tons valued at $1.6 million, (ii) 800 tons of baitfish (for tuna fishing) valued at $0.1 million, and (iii) exports of about 950 tons valued at $1.6 million.

As trochus and sea cucumber are both easy to harvest and are nonperishable, coastal communities in Solomon Islands tend to target harvest of these species, particularly in the face of poor storage facilities and weak transport links. Unpublished data sourced from MFMR report an estimated value of trochus and sea cucumber exports of $5.6 million for the decade ending in 2010. However, when the sea cucumber fishery appeared to be headed for collapse, the government imposed a national ban on both the harvest and export of sea cucumber. In 2006, records from the then Department of Fisheries and Marine Resources showed that sea cucumber exports are mainly composed of low-value species (Nash and Ramofafia 2006). Unfortunately, the trochus fishery now appears to be following a trend similar to that of the sea cucumber fishery. A study performed by the Secretariat of the Pacific Community in 2006 at four Solomon Islands trochus-harvesting sites found low densities of trochus compared with similar sites in other Pacific island countries (Pinca et al. 2009). Declining trochus catches over the past few decades similarly suggest that current extraction rates in the country's trochus fishery are unsustainable.

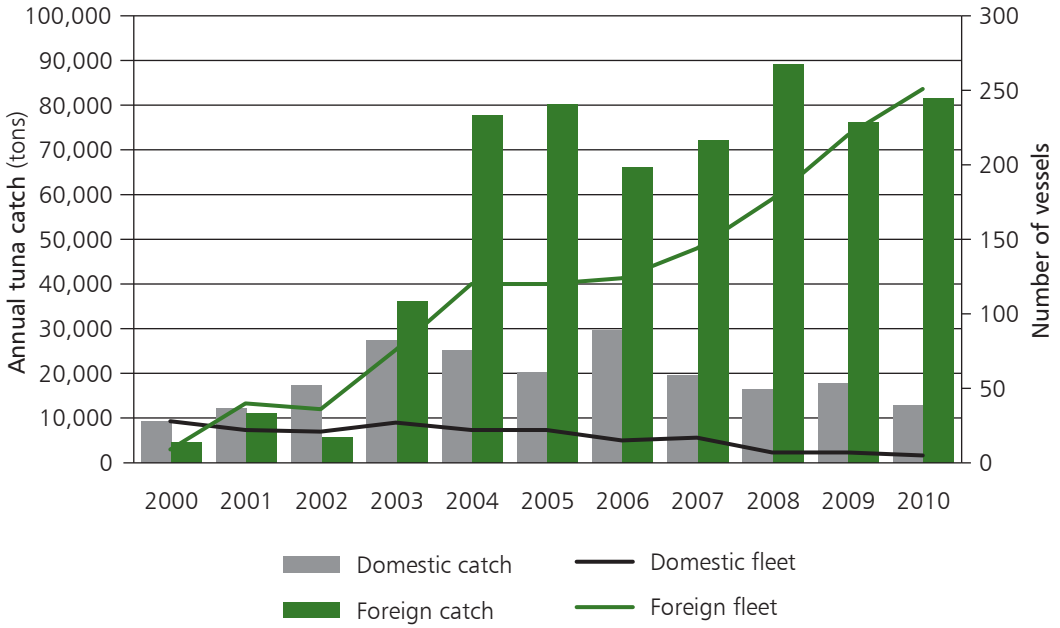
Commercial tuna fisheries

The commercial tuna industry is a vital source of revenue for the Solomon Islands government. Over the past decade, licensing fees collected from foreign and domestic fleets averaged $4.5 million annually. This figure represents a significant rebound from the early 2000s when tuna revenues declined drastically in 1999 and the early 2000s as a result of ethnic tension. As a number of major fishing companies suspended operations in Solomon Islands during the height of the ethnic tension in 2000, annual domestic production fell below 10,000 tons from a previous peak of 50,000 tons (CBSI 2001). However, the rebound in total annual catch in previous years has been significant, with the highest catch level recorded by the domestic fleet since 2000 reaching 29,615 tons in 2006 (Figure 2). Similarly, the foreign fleet recorded its largest catch at 89,275 tons in 2008. Total catches increased during this decade as the size of the foreign fleet grew. However, this coincided with a decline in the size of the domestic fleet. Tuna catches over the past decade have been dominated by skipjack and yellowfin tuna (Figure 3), majority of which were caught by the foreign fleet.

Resource use

The term "home production" refers to goods and services (typically, fruit, vegetables, and fish) produced by an individual household that are predominantly consumed by that same household, or given as gifts to another household (Solomon Islands National Statistics Office 2006). However, Solomon Islands statistics on home production are typically not disaggregated into garden produce and fish as separate categories. That said, what is known is that more than half (56%) of the country's rural households rely on home production as their major source of household income. This contrasts sharply with urban households, only 5% of which rely on home production as the major source of income. This difference is also reflected in the percentage share of annual average food consumption expenditure spent on fish (including shellfish), which for urban residents is 17% but for rural residents, only 13% (Table 3). Given these latter percentage shares, it is unsurprising that the absolute value of expenditure on fish

Figure 2 **Annual Tuna Catch in Solomon Waters by Foreign and Domestic Fleets, 2000–2010**



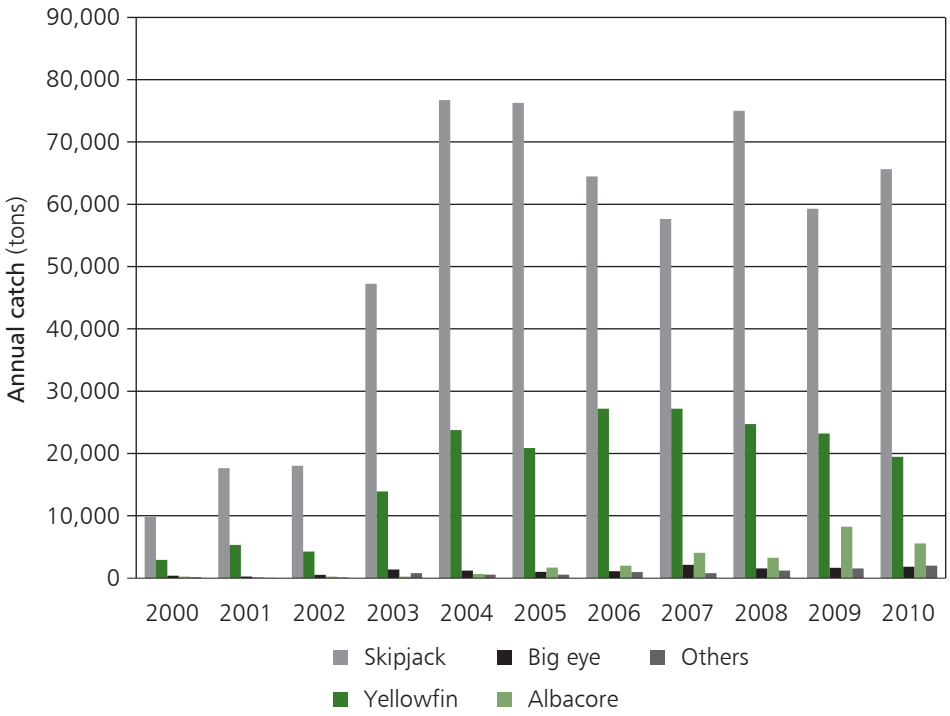
Source: Ministry of Fisheries and Marine Resources. 2010.

purchases in the urban centers exceeds that in rural areas (Solomon Islands National Statistics Office 2006).

Fish, including shellfish and other inshore marine resources, play a vital role in both food security and income generation in Solomon Islands. In fact, the country has one of the highest per capita rates of fish consumption in the entire world. Although available estimates vary (Table 4), Bell et al. (2009) estimate average annual per capita fish consumption in the urban areas at 45.5 kilograms (kg) compared to 31.2 kg in rural areas. Interestingly, fresh fish account for 90% of the national annual per capita fish consumption of 33 kg. However, these figures may be underestimates (Weeratunge et al. 2011), as a survey performed by Pinca et al. (2009) that included four separate locations estimated annual per capita fish consumption at 98.6 kg–110.9 kg.

Regardless of the significant variation in the above estimates of national annual per capita fish consumption, Solomon Islands fisheries indisputably contribute significantly to national income. Reef fisheries alone contribute an estimated $2.8 million to the annual income of fishers and traders who are in one way or another associated with the reef fisheries market (Brewer 2011). Further, as this latter estimate predominantly relates to reef finfish, it ignores the annual income derived from the trochus and (currently closed) sea cucumber fisheries, as well as the country's trade in marine ornamentals. Ultimately, these latter fisheries likewise contribute significantly

Figure 3 **Tuna Catch by Species, 2000–2010**



Source: Ministry of Fisheries and Marine Resources. 2010.

to income generation in Solomon Islands, particularly in the country's rural areas. The overall level of annual income derived from the country's reef fisheries is thus undeniably substantial.

Fishing is a major income-generating activity for many Solomon Islanders, particularly those in the rural areas. Nevertheless, fishing and related activities account for only a small percentage of formal employment as officially reported. Given this, official employment statistics typically lump fishing with figures for the agriculture sector overall, making any attempt at estimating the contribution of fisheries to total formal employment an exercise fraught with error. Typically, statistics regarding formal employment in the fisheries sector include only (i) officers of large-scale fishing companies; (ii) fishers who work on industrial-scale fishing boats; (iii) employees of tuna canneries in Noro, Western Province; (iv) MFMR employees; and (v) employees of the South Pacific Forum Fisheries Agency, which is based in Honiara.

Issues in capture fisheries

Given the significant contribution of fisheries to both national income and income generation at the household level, balancing the degree to which Solomon Islands fisheries are used to fuel economic development, provide the government with a source of revenue, and raise the average income of rural Solomon Islanders is a difficult task. This is particularly true of the country's significant rural household sector, which currently relies heavily on the country's fisheries as both a source of dietary protein and household income. Given such pressures, guarding against overfishing is a difficult task. In this regard, the calculations of Bell et al.

Table 3 Fish Production and Consumption Statistics for Rural and Urban Areas of Solomon Islands

	Urban	Rural	National
Percentage share of fish in annual per capita food expenditure	16.90	12.98	14.49
Percentage share of households engaged in home production[a]	4.81	55.89	36.90
Percentage share of households engaged in the sale of fish and other seafood in the total number of households engaged in self-employment and related small business	9.34	16.44	15.93

Notes:

[a] "Home production" refers to the value of goods and services produced annually by an individual household that are predominantly consumed by that same household, or given as gifts to another household. While "home production" is typically composed of fruits, vegetables, and fish, disaggregated statistics for these three components of home production are not currently available.

Source: 2005–2006 Household Income and Expenditure Survey, Solomon Islands National Statistics Office. 2006.

Table 4 Annual Per Capita Fish Consumption in Solomon Islands 1983–2009 (kg)

Year	Per Capita Consumption	Source
1983	26.0	1983 Statistics Office Survey
1988	Fish: 22.0 Shellfish: 12.0	1988 Statistics Office Survey
1990	35.0 overall	Skewes (1990)
2002	45.5 overall	Solomon Islands, Secretariat of the Pacific Community report
2009	Rural households: 31.2 Urban households: 45.5 National average: 33.0	Bell et al. (2009)
2009	98.6–110.9	Pinca et al. (2009)

Source: Compiled by authors.

(2009) are of particular concern. This study estimates that the sustainable annual production of the country's coastal fisheries is 11,150 tons. In contrast, based on the quantitative nutritional requirements published by the government in 2010, the fish requirement of Solomon Islanders projected for 2030 is estimated at 18,000 tons. In short, over the coming decades, overfishing could become a significant challenge to further economic development.

Not only are opportunities for income generation limited in rural areas but the overall lack of development in such locales itself also mitigates against risk-taking at the level of micro- or small-scale business. In turn, this limited level of economic activity in rural areas means that economies of scale in transport are not possible, a factor that translates into significant per-kilometer transport costs. When coupled with the distance at which buying centers for local products are located, such transport costs make micro- or small-scale business in the rural areas uneconomic. This is reflected in the fact that unpublished MFMR data indicate that only 46% of the country's 30 RFCs—which were put into place with donor assistance and to some degree operated under government budget—were reported to be operating in 2010.

Aquaculture

Aquaculture in both its marine and freshwater forms is still a nascent industry in Solomon Islands. As a result, its contribution to household protein intake is minimal. However, in light of the possible decline in catches from capture fisheries as projected above (Bell et al. 2009, Weeratunge et al. 2011), aquaculture is expected to play a significant role in filling the gap between the requirements for fish and the amount that can be harvested from the country's fisheries.

Currently, aquaculture is limited to the culture of seaweed, some corals, and clams for the marine ornamental trade. While the 1980s and 1990s saw limited shrimp (*Macrobrachium* and penaied shrimp) output, the farms responsible for this production have ceased operations (WorldFish Center 2011). During the mid-1990s and early 2000s, the WorldFish Center performed research on blacklip (*Pinctada margaritifera*) and goldlip pearl oyster (*P. maxima*) culture, as well as other aquaculture-based commodities such as the Pacific bath sponge (*Coscinoderma mathewsi*). This research ultimately aims to expand the range of income-earning opportunities for rural communities, particularly with regard to nonperishable commodities. Table 5 identifies the aquaculture commodities prioritized by MFMR in its 2009–2014 Aquaculture Development Plan. These commodities—most of which are marine-based, easy to produce, and potentially profitable—could help meet the future food and income requirements of numerous rural Solomon Islanders.

Table 5 **Potential Economic Development Impact and Financial Feasibility of Aquaculture-Based Commodities Suggested for Production in Solomon Islands**

Commodity	Potential Economic Development Impact	Financial Feasibility
Coral	Medium	Medium
Crocodile	High	Low
Crustaceans	Medium	Medium
Eel	Medium	Low
Giant clam	High	Medium
Live rock	Medium	Medium
Milkfish	Medium	Medium
Mud crab	Medium	Low
Ornamental fish	Medium	Low
Pearl	Medium	Medium
Sea cucumber	High	Medium
Seaweed	High	High
Shrimp, freshwater	Medium	Medium
Shrimp, marine	Medium	Low
Sponge	Medium	Medium
Tilapia	High	Medium
Trochus	Medium	Medium

Source: Ministry of Fisheries and Marine Resources. 2010.

Seaweed (*Kappaphycus alvarezii*)

Seaweed culture in Solomon Islands began in 1988 in two sites located in Western Province. In 2000, seed stocks from trials at these sites were collected for further trials at other provincial sites (e.g., Rarumana) that Wale (2003) suggested would be successful and would provide significant socioeconomic benefits. Although initiatives under the European Union's year-2000 Rural Fisheries Enterprise Project attempted to link these sites, this proved unsuccessful for a number of reasons. Then in 2004, the Commercialization of Seaweed Production in Solomon Islands project assisted the establishment of seaweed storage and marketing facilities in Wagina, Choiseul Province, which succeeded in expanding the number of seaweed farmers in the project area. By the end of 2005, 130 farmers had begun seaweed farming in Western Province, about 300 in Choiseul Province, as well as others in Malaita and Makira. By 2010, 14 seaweed production sites had been established. Based on MFMR estimates, 250–300 seaweed farmers were active in 2011.

Despite the success in expanding seaweed production referred to above, total seaweed output in Solomon Islands significantly fluctuated during these years. The major reasons for this included (i) low prices, (ii) the fungal disease "Egyptis," and (iii) prohibitive transport costs (Kronen et al. 2010a). A tsunami in April 2007 further lowered output as it destroyed several production sites, including particularly important ones in Wagina and Rarumana. In 2004, prices were reported at SI$2/kg ($0.28/kg) (CBSI 2007). An inquiry in February 2012 at the office of the sole seaweed license holder and exporter in the country showed a buying price of $0.77/kg in Honiara and $0.70/kg in outlying provinces. Figures for 2005–2010 obtained from MFMR indicate that annual production fluctuated between 84 tons and 645 tons, the value of total production in 2010 being worth SI$4.5 million ($0.6 million) (Figure 4).

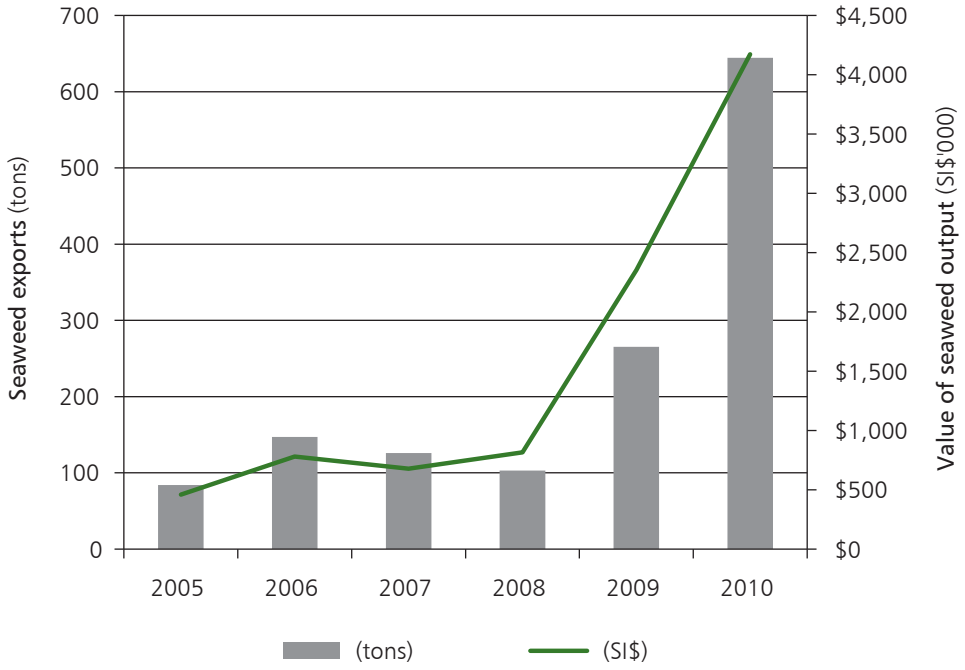
Pearl oysters

Blacklip, goldlip, and brownlip (*Pteria penguin*) pearl oysters were important cash commodities for Solomon Islands rural communities until a national ban was imposed in 1994. Beginning with the period 1968–1972, harvests occurred in pulses until stocks fell to unsustainable levels and further production became uneconomic. The second pulse occurred in 1987–1994 (Hawes 2008). At its peak in 1991, 45 tons of mother-of-pearl shells valued at $200,000 were exported. In response to the depleting stocks, in the early 1990s then Department of Fisheries and Marine Resources and the WorldFish Center began research on farming blacklip pearl oysters, which continued into the early 2000s when the first pearls were sold. However, no commercial farming of pearl oysters has occurred to date in Solomon Islands, despite research indicating that such production would be economic. This in large measure was a response to the civil unrest that occurred in the late 1990s, which severely depressed commercial investment. More recently, lack of participation by Solomon Islanders was probably due to lack of start-up capital.

Pacific sponge (*Coscinoderma mathewsi*)

Sponges have been farmed in the western Pacific for many years (Hawes and Oengpepa 2010), though success has been limited at the regional level. Nevertheless, sponge culture is an economic activity in Solomon Islands as sponges are native species, occur naturally, can be easily processed into a nonperishable form, do not need to be transported in the live state, and are of relatively light weight, making their value per unit weight relatively high. All of these

Figure 4 **Volume and Value of Seaweed Exports from Solomon Islands 2005–2010**



Source: Ministry of Fisheries and Marine Resources. 2010.

attributes similarly suggest that sponge farming would be economic in the rural setting where transport costs are prohibitive for more delicate commodities such as corals and clams. Research on sponge culture in Solomon Islands has included techniques for ensuring environmental sustainability, and for producing sponges in appropriate sizes and shapes for the niche markets where they are popular. Although simple production techniques have been identified and sponge samples have been produced for an initial market assessment by New Zealand–based marketers, identifying niche markets where prices are relatively high would better sustain the industry in Solomon Islands.

Freshwater species

MFMR's 2009–2014 Aquaculture Development Plan highlighted the importance of expanding freshwater aquaculture as a means of providing fish in areas with limited access to inshore fisheries. Tilapia was one of four aquaculture commodities identified as being financially feasible, and potentially of significant importance to increasing household incomes. As a result, the Solomon Islands *Tilapia Aquaculture Plan 2010–2015* was published in 2010. This plan identified tilapia as a preferred freshwater species for helping Solomon Islands meet its fish requirements. While the Mozambique tilapia had already been introduced to Solomon Islands, a national decision still needed to be made regarding the introduction of Nile tilapia. In 2010, MFMR, the WorldFish Center, and the Secretariat of the Pacific Community began the first phase of the Aquaculture and Food Security in the Solomon Islands project. The objective of this project was to identify the best means of implementing an inland aquaculture program

for contributing to the food and nutritional security of Solomon Islands. This project primarily focused on tilapia and milkfish.

The initial assessment performed under the project found small backyard tilapia ponds on several of the country's major islands. Guadalcanal and Malaita had the greatest concentrations of such ponds, which numbered 50–100. However, the yields of all of these ponds were relatively low, in that they produced fewer than 5 tons annually. The assessment also found that nearly all farmed tilapia in Solomon Islands were raised for household consumption. The low yields of these ponds notwithstanding, the farmers interviewed under the assessment were generally enthusiastic about culturing fish.[7]

The overall results of the assessment indicate that while market demand for tilapia and milkfish in Solomon Islands was likely to be significant, considerable investment in research, technology, information dissemination, and infrastructure were required for tilapia farming to be successful. This project is currently in its second phase, the focus of which is to improve Mozambique tilapia–farming techniques, and to determine the feasibility of farming native milkfish.

Marine Ornamental Trade

The marine ornamental trade in Solomon Islands primarily focuses on corals, cultured clams, and aquarium fish, each of which is discussed in turn below.

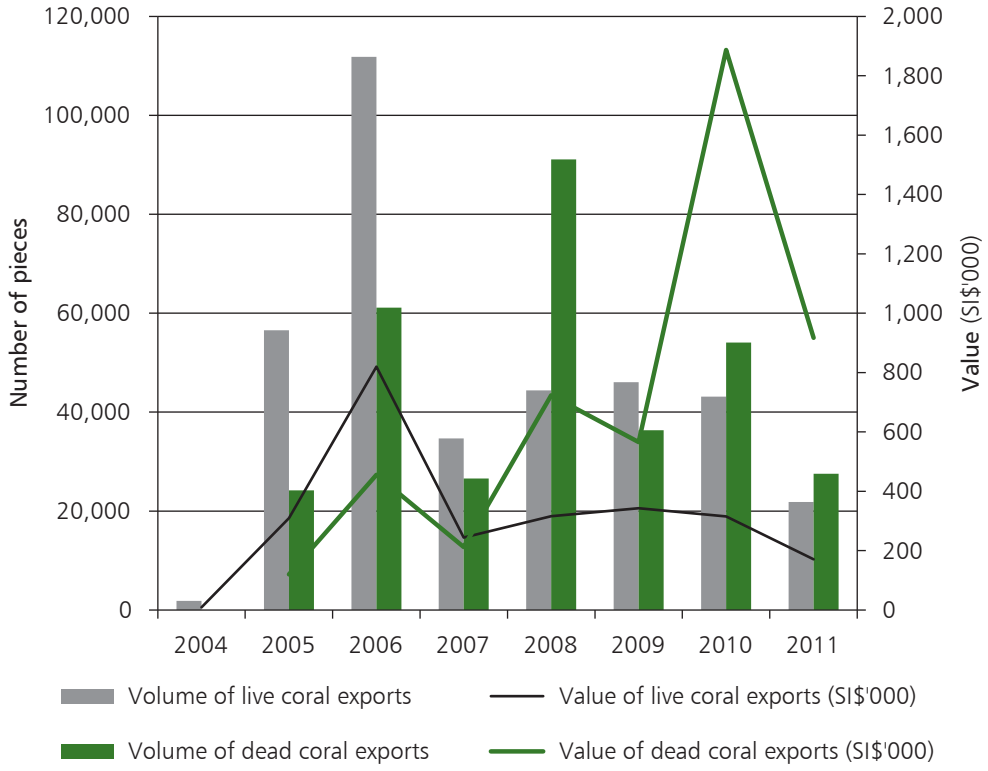
Corals

The aquarium trade in Solomon Islands, established in 1995 (Kinch and Teitelbaum 2009), initially focused on the export of live corals by the Solomon Islands Marine Export and Aquarium Arts Solomon Islands (MEAASI), and dead corals by Solomon Sea Stones. In 2003, aquarium trade exports from Solomon Islands accounted for 4% of the international coral trade (Wabnitz et al. 2003). By 2011, MEAASI was the sole exporter of live coral, and two companies, Halelo and Sea Abundance, were exporting dead coral. These corals were mainly supplied by communities in Central, Guadalcanal, and Western provinces. In fact, Lal and Kinch (2005) reported that about 75% of all coral exports from Solomon Islands originated in Nggela (Florida Islands) in Central Province.

Indicative figures provided by MFMR in 2011 (Figure 5) report that the value of live coral exports initially exceeded that of dead corals. However, the value of dead coral exports for the curio trade expanded rapidly in 2008, and then peaked in 2010. Thus, while the volume of dead coral exports fell over the period 2008–2010, their value increased dramatically over the same period. The reason for this increase in value per unit of dead coral resulted from a deliberate change in MFMR policy, the objective of which was to raise the prices that dead corals fetched. More specifically, before 2008, dead corals were exported by the container-load, and were thus sold in bulk at relatively low prices per unit. In contrast, after 2008, dead corals were sold by the piece and according to specific species, a change that resulted in much higher prices than under the bulk-sales arrangement. This subtle change in policy allowed the value per unit of

[7] Approximately 60% of the 178 households surveyed on Guadalcanal and Malaita expressed an interest in culturing fish.

Figure 5 **Volume and Value of Exports of Live and Dead Corals from Solomon Islands, 2004–2011**



Source: Ministry of Fisheries and Marine Resources. 2010.

dead coral exports from Solomon Islands to increase dramatically and, along with it, the foreign exchange earnings from Solomon Islands coral exports.

Curio Trade

Sea Abundance, a private company focusing on the export of dead corals for the international curio trade, began operations in 2005. Following a brief fall in the value of dead coral exports in 2007 (Figure 5), total export value increased significantly in 2009. This increase in export value largely resulted from an increase in exports by Solomon Sea Stones, a company licensed to export 19 coral species. Together with the change in MFMR policy under which dead corals were sold by the piece and according to species, the Ministry of Environment, Climate Change, Disaster Management and Meteorology (MECDM) established a system of export quotas that applied to selected species from eight coral families (Table 6), the aggregate coral export quota for all species in 2010 being 92,000 pieces. An assessment of coral exports from Solomon Islands in 2005–2011 reported that approximately 79% of all coral exports during this period were destined for US-based markets.

Table 6 **Coral Families Subject to Solomon Islands Export Quotas**

Coral Family	2010 Export Quota (pieces)
Acroporidae	32,000
Pocilloporidae	28,000
Milleporidae	4,000
Merulinidae	8,000
Agariciidae	8,000
Helioporidae	4,000
Tubiporidae	4,000
Funggidae	4,000

Source: Ministry of Environment, Climate Change, Disaster Management and Meteorology. 2011.

Coastal Tourism

The coastal tourism industry is a growing source of income for Solomon Islands, although it has started from a relatively small base as tourist arrivals are relatively small compared with people visiting Solomon Islands for business purposes. In fact, a 2006–2007 international visitor survey reported that tourist arrivals accounted for only 21% of total foreign visitor arrivals. In aggregate, the total expenditure of all tourist arrivals for the year surveyed was approximately $3.9 million.

The majority of tourism-related economic activity focuses on the country's coastal areas and tourist activities there. Apart from Honiara, the major tourist destination is Western Province, as tourist destinations there are easily accessed by plane and, in most cases, a short boat ride. In fact, Solomon Islands has done an excellent job of marketing the popular tourist image of sun-soaked tropical islands in the South Pacific where a relaxed lifestyle predominates, as the country's most popular tourist activities include snorkeling, scuba diving, surfing, game fishing, and tours of mangroves. More recently, village stays have also become popular among tourists. This is a valuable income-generating activity for local residents as it allows them to increase household income while maintaining traditional ways of living, such as baking food in stone ovens.

Minerals, Oil, and Gas

Mineral, oil, and gas extraction is not well developed in Solomon Islands. Currently, only two mining companies—Allied Gold and Solomon Alluvial Mining Ltd.—are active, both of which extract gold and other minerals solely in Guadalcanal Province. That said, numerous submissions for tenements for prospecting minerals have been submitted to the Ministry of Mines, Energy, and Rural Electrification. Exploration for mineral deposits is likewise ongoing. The current administrative process regarding mining and prospecting tenements provides a maximum prospecting time frame of 7 years, following which extraction must either begin, or the enterprise concerned must depart the country.

As of September 2011, 15 companies have submitted about 77 tenements for prospecting in Solomon Islands, 23 of which relate to offshore prospecting by two companies. It also appears that the total number of tenements awaiting decisions by the Ministry of Mines, Energy, and Rural Electrification is likely to increase. Offshore exploration activities mainly target copper, gold, silver, and zinc, while onshore prospecting targets arsenic, antimony, bauxite, cobalt, copper, gold, iron, manganese, molybdenum, nickel, silver, tellurium, zinc, and other minerals. Majority of the companies and tenements are located in Western and Guadalcanal provinces.

Solomon Islands produces no oil, although some petroleum exploration was performed in the early 1980s. These explorations were based on geological land surveys and marine geophysical profiling. The results of these explorations indicated that some sites held the potential for oil production. They likewise made recommendations for further surveys that might fully evaluate particular sites.

Environmental issues in mineral, oil, and gas extraction

Many potential mining locations in Solomon Islands are adjacent to intact and diverse coral reef ecosystems in Choiseul, Isabel, and Western provinces. Most current environmental issues relating to mining and prospecting have arisen as a result of reports by residents of Guadalcanal communities located downstream from extraction activities. A number of these reports have been investigated by the appropriate authorities, and relate to negative impacts resulting from spills of slurry or waste oil, or damage to pipe systems, the latter causing concerns over leakage of cyanide, which can cause deforestation as well as pollution of underground water and the marine environment generally. Some reports allege that streams are no longer suitable for human use as a result of raw tailings being spilled into nearby rivers and streams. Others report degraded water quality or the presence of dead animals.

A more disconcerting finding of this report is the lack of transparency surrounding the reporting and documentation of the environmental impacts of mining. Discussions with relevant authorities revealed that no actual documentation detailing the negative environmental impacts of mining activities was available, despite frequent on-site assessments. As a result, this report had to rely on reports of the environmental impacts of mining published by national newspapers.

Domestic Shipping

As a maritime nation, Solomon Islands depends more heavily on shipping than on aviation or land transport. Owing to the country's geographical spread across a relatively vast oceanic expanse, domestic sea transport is the major mode of transport for most people and is thus an important sector of the economy. In fact, shipping companies provide transport services to nearly all nine provincial groups. While most services run between Honiara and provincial urban centers, others service all villages adjacent to their shipping routes. While more populous urban centers such as Auki in Malaita Province, Buala in Isabel Province, and Gizo in Western Province enjoy regular services, most destinations depend on services whose frequency depends on the number of passengers, as ship owners tend to only make trips that are profitable.

The range of goods transported to and from the country's rural and urban areas is extensive. For routes originating in Honiara, the cargo is mainly composed of imported foodstuffs—such as rice, flour, and biscuits—that are mainly sold in shops in provincial urban areas and village canteens, though building materials are also popular cargo items. As might be expected, garden produce and other crops such as betel nut, cocoa, and copra account for most cargo on routes departing outer-island locations for Honiara, as these items are popular with buyers and markets there. Similarly, fresh seafood transported in large coolers and other marine products likewise tend to dominate cargo destined for Honiara.

International Shipping

Most goods of overseas origin arrive in Solomon Islands by international sea transport, as air transport is a much costlier alternative. Solomon Islands is served by two major international shipping ports, one located in Honiara and the other in Noro. Tuna is the country's major fish export, most of which is exported from Noro as a cannery is located there. Logging ships also sail internationally directly to and from points where logs are collected for export. Data on shipping traffic into Solomon Islands are available both from shipping agents and the Solomon Islands Ports Authority. However, for security reasons, these data were unavailable to the authors of this report. That said, maps of shipping-container and oil-tanker traffic in the Pacific were available from the Secretariat of the Pacific Regional Environment Programme (SPREP) (Hay et al. 2003). These maps show that Solomon Islands lies within major shipping routes in the South Pacific.

Transport and Shipping Issues

Transport and shipping play a major role in both the exploitation and protection of coral reefs. Shipping services serve urban areas that enable exploitation of and trade in coral reef resources, including those that originate in remote parts of Solomon Islands. Similarly, most materials and equipment used for exploiting coral reef resources arrive both in the country and in rural areas on ships. The shipping industry thus enables activities that pose the greatest threats to coral reefs in Solomon Islands. These threats include (i) grounding on reefs by domestic ships and international carriers arriving to load logs for export; and (ii) discharge by international shipping services of both contaminated ballast water and invasive species that live in it (see the section on harmful algal blooms and discharge of ballast water below), as well as pollution from oil spills. While no documentation concerning these is available, anecdotal reports of domestic interisland vessels dumping waste oil directly into the sea are relatively common. Similarly, the coastline near Honiara and other locations are dotted with condemned or wrecked ships that slowly release waste oil into the marine environment. In addition, Solomon Islands shipping yards and slipways use significant quantities of chemicals, oil, and paint, the discharge of which threatens the country's coral reefs and marine environment. Finally, pollution from the construction and maintenance of infrastructure at the country's ports and numerous wharfs likewise threatens the ecological integrity of the coral reefs.

Reuben Sulu

A shipwreck on the shore of Solomon Islands.

Threats and Vulnerabilities

Current Issues in Marine Resource Management

Degradation of fisheries and food security

As earlier discussed, fish play a central role in the livelihood of most Solomon Islanders, both as a source of dietary protein and cash income. This is particularly true of the significant portion of the population that extracts the fish that it either consumes or sells from the country's coral reef fisheries. Since these fisheries constitute a finite resource, allowing extraction rates from them to exceed maximum sustainable levels will inevitably cause the total catch to decline. Unfortunately, a growing body of evidence suggests that the maximum sustainable rate of extraction from the country's coral reef fisheries has either been reached or exceeded (Newton et al. 2007).

What is known with reasonable certainty is that the annual catch required to ensure adequate dietary protein intake of Solomon Islanders is 18,000 tons. However, this annual catch level already far exceeds the estimated sustainable production capacity of the country's entire coastal fisheries, which is estimated at 11,150–13,800 tons. Further, in light of the current annual population growth rate of 2.3% (Solomon Islands National Statistics Office 2011) and other factors, the total annual catch required for adequate dietary protein intake is projected to increase to 25,500 tons in 2020 and 29,900 tons in 2030 (Bell et al. 2009).

Such projections suggest that if the country's expanding requirement for dietary protein is not increasingly met from sources other than its coastal fisheries, depletion of this resource is inevitable, which in turn implies increasing food insecurity. Unfortunately, the default short-term response of most fishers to such a scenario would likely be further expansion of overfishing and use of destructive fishing methods. In all probability, this scenario is already playing out, particularly in geographic areas that are either population dense or adjacent to markets. Indeed, Sabetian and Foale (2006) conclude that expanding consumption and income generation requirements have significantly increased extraction rates for the country's fisheries overall. This has in turn resulted in declining catches for a number of species such as parrot fish (Hamilton et al. 2005, Aswani and Sabetian 2009, Brewer et al. 2009); sea cucumber (Kinch 2004, 2005); giant clams; and green snail. While not yet formally documented through field surveys, several species of shark may be more threatened than is realized, as these are often casualties of longline fishing and targeted for their fins, which are exported to Asian markets as a delicacy.

Destructive fishing practices

Destructive fishing practices include both traditional and modern methods. A number of anecdotal reports suggest that traditional fish-stunning methods (e.g., use of *Barringtonia asiatica* and sea cucumber extractions) are declining. However, in many parts of Solomon Islands, the traditional practice of stunning fish with derris root (e.g., *Derris eliptica*) is still common. Nevertheless, the most widespread destructive fish harvesting method employs dynamite or other explosives extracted from World War II–era ammunition. Use of this method—which physically destroys the reef itself in addition to killing fish—appears to be concentrated in Langalanga lagoon (Malaita), Nggela, and parts of Guadalcanal (Burke et al. 2011), with anecdotal reports of some use in Lau lagoon in Malaita (J. Bou, personal communication, 2012). Dynamite fishing typically targets schooling species such as *Selar crumenopthalmus, Rastrelliger kanagurta, Naso* species, and *Kyphosidae* species, and occasionally, juvenile carangids that forage inshore (R. J. Sulu, personal observation, 2012).

A study of dynamite fishing in Nggela by Sulu (2010) concludes that the major factors perpetuating its use are the following:

- high catch returns per unit effort, particularly by semicommercial fishers;
- weak or lack of enforcement of legislation prohibiting dynamite fishing; and
- declining respect for traditional leaders, who previously enforced a prohibition against dynamite fishing at the community level (Wairiu and Tabo 2003).

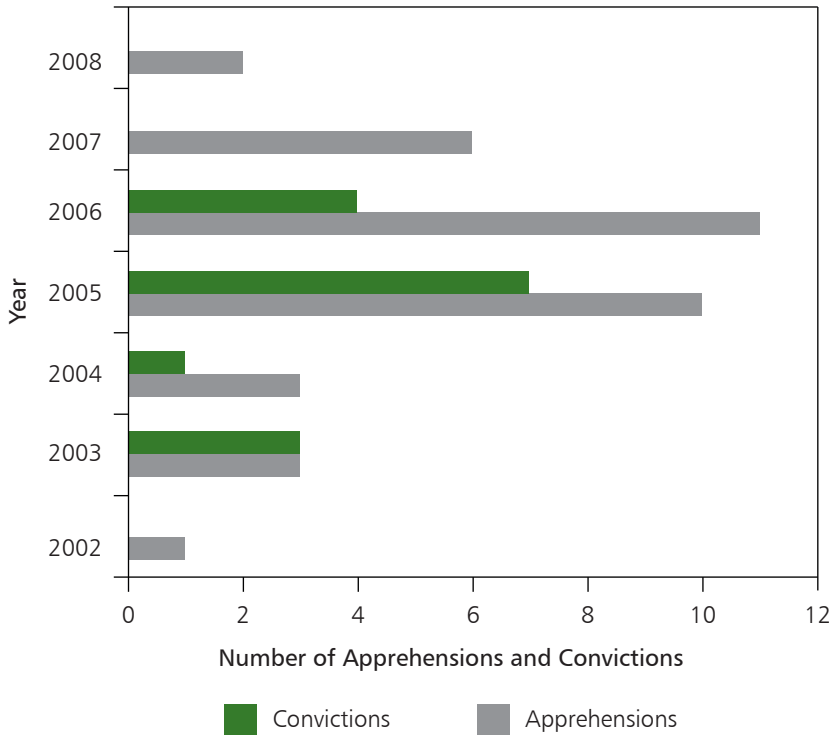
Ultimately, the perception of traditional leaders and dynamite fishers alike is that community leaders lack the authority or the protection of law to enforce prohibitions against dynamite fishing and to prosecute offenders. Thus, apprehension of dynamite fishers generally results from sporadic police patrols undertaken only when fuel is available. Apprehension rates are thus relatively low. For example, over January 2000 to May 2008, only 36 dynamite fishers were apprehended by the Nggela police, and only 15 of these were ultimately convicted (Figure 6). Because of the significant cost of enforcing prohibitions against dynamite fishing in a geographic area as large as the country's coastal fisheries, successfully addressing dynamite fishing requires a combination of modern governance methods and the support of the local community concerned. The latter includes empowering community governance structures to enforce dynamite fishing prohibitions at the local level (Aswani 1997b, Lidimani 2006).

Threatened species

Turtles

Government surveys conducted from 1973 to 1982 show that the nesting grounds for the three species of turtles found in Solomon Islands (hawksbill, green, and leatherback) are both geographically dispersed and species-specific. For example, the Shortland Islands and Ramos Islands in Malaita were reported to be the major nesting grounds for hawksbill and green turtles, while the Russell Islands, Helebar Islands in Marovo, and Santa Cruz (not within the Coral Triangle) were reported to be important hawksbill nesting sites. In contrast, the most important nesting beaches for leatherback turtles were reported to be Vacho and Sasamunga islands in Choiseul, Sasakolo and Litogahira in Isabel, Rendova, and Tetepare in Western Province. Overall, the ACMCA was reported to be an important turtle rookery.

Figure 6 **Dynamite Fishing Apprehensions and Convictions, 2002–2008**



Source: Tulagi Police Department and Sulu. 2010.

The only Solomon Islands nesting site with consistent monitoring of nesting of hawksbill and green turtles since the early 1990s is ACMCA (see photo on page 40). Spread over three small uninhabited islands that total 16,000 ha, the Government of Solomon Islands declared it a wildlife sanctuary in 1980, owing to its importance as a nesting ground for both hawksbill and green turtles. Over the past 20 years, The Nature Conservancy has partnered with MECDM (previously Department of Environment) and MFMR (previously Department of Fisheries) in monitoring turtle nesting. Early reports by Vaughan (1981) estimated that ACMCA supported about 600 nests (550 hawksbill and 50 green turtles) per year. However, recent monitoring (P. Ramohia, personal communication, 2012) suggests that ACMCA annually supports as many as 1,800 nests of these two species taken together.

Historically, marine turtles have played an important role in Solomon Islands culture, as evidenced by displays of turtle carvings in national museums, contemporary carvings, and numerous local legends and beliefs. Turtle eggs and meat remain a delicacy consumed on special occasions, while turtle shells and oil are used for cultural and traditional purposes. Local artisans make traditional ornaments (e.g., rings, bangles, and earrings) from turtle shells for sale in local markets. Unfortunately, this cultural use of turtles has led to their overexploitation.

Since 1993, the government has imposed a total ban on both the harvesting of turtles and the export of turtle shells during the nesting season, which extends from June to August and November to January. Although use of turtles for subsistence purposes continues at the

The Nature Conservancy

An aerial view of the Arnavon Community Managed Conservation Area.

local level, commercial export of turtle shells ceased in the wake of the government's fisheries regulations coming into effect. Similarly, there is growing effort at the international level to protect the nesting sites of the leatherback turtle, which is an endangered species (Pacific Horizon Consultancy Group 2008). In Solomon Islands, turtle protection and conservation are carried out through partnerships with all stakeholders including residents of local communities, both the national and provincial governments, community-based organizations, nongovernment organizations (NGOs), regional organizations, and donor agencies.

Dolphins

A study by Leary and Pita (2000) suggests that nine dolphin species are present in Solomon Islands waters. Of these, the most common are spinner dolphin (*Stenella longirostris*), common bottlenose dolphin (*Tursiops truncatus*), Indo-Pacific bottlenose dolphin (*Tursiops aduncus*), and pan-tropical bottlenose dolphin (*Stenella attenuate*) (Kahn 2006, Oremus et al. 2011). The rankings concerning the abundance of these species vary among researchers, probably as a result of differences in geographic location, as well as the seasons during which the various surveys were performed. Goto et al. (1997) conducted surveys in offshore waters in the area defined by 4°S–13°S and 155°E–163°E, while the surveys by Kahn (2006) spanned the area from Shortland Islands to Makira. Surveys performed by Oremus et al. (2011) focused on the area bounded by Eastern Santa Isabel, Florida Islands, Malaita, and North Guadalcanal. Both individual counts and the frequency of sightings in Solomon Islands seem to indicate a low level of species diversity and abundance compared to those in Eastern Indonesia and northern Papua New Guinea (Kahn 2006). A cetacean distribution map of central Solomon Islands derived from surveys conducted in 2009 and 2010 shows that of all dolphin species sighted during

Table 7 **Dolphin Catches at Fanalei, 1965–2005**

Year	Number of Animals	Source
1965	2,000	Kahn (2006)
1994	865	Takekawa (2000)
1999	700	Kahn (2006)
2000	800	Kahn (2006)
2002	700	Kahn (2006)
2003	1,200	Kahn (2006)
2005	600	Kahn (2006)

Sources: Takekawa (2000) and Kahn (2006).

Table 8 **Exports of Live Dolphins from Solomon Islands, 2003–2011**

Year	Number	Destination Country
2003	28	Mexico
2007	28	Dubai
2008	18	Singapore
2008	7	Philippines
2009	9	Malaysia
2009	11	Philippines
2011	25	China, People's Republic of

Source: UNEP-WCMC. 2012.

these surveys, *Stenella longirostris* was more frequently sighted in Florida Islands and north Guadalcanal, while *Tursiops aduncus* was more frequently sighted in east Isabel. Sightings of *T. aduncus* were less frequent in Malaita. However, the pods sighted were generally larger than those in the waters off northern Guadalcanal (Oremus et al. 2011).

Some Solomon Islands communities have a long history of hunting dolphins, both for direct consumption and for their teeth, which are used as traditional currency and as ornaments and jewelry (Dawbin 1966, Takekawa 2000). These practices are particularly common in North Malaita, Langalanga, and the communities of Fanalei and Walande in South Malaita. In recent years, only the communities of Bita'ama in North Malaita, Fanalei, and Walande have participated in dolphin hunts. The hunting period in Fanalei is generally January to April, which coincides with calm weather (Takekawa 2000, Kahn 2006). Catch records derived from available literature are summarized in Table 7. These catches mainly consisted of pan-tropical spotted dolphins and spinner dolphins (Takekawa 2000).

Live capture of dolphins (*Tursiops aduncus*) began only in 2003. The dolphins thus harvested are held in pens and then exported to overseas aquariums and marine parks. However, in 2003 the Government of Solomon Islands placed an annual limit on the number of dolphins that may be exported, the limit in 2003 being 100 live dolphins for all species combined. That said, this limit was never reached in any year since live dolphin exports have been permitted. Table 8 shows both the number of live dolphins exported from Solomon Islands, as well as the corresponding destination countries for the period 2003–2011.

Numerous entities have criticized the capture of live dolphins for export, including environmental activists, environmental organizations, intergovernmental groups, and foreign governments. These groups have voiced two major concerns. First, Solomon Islands lacks an overall dolphin management plan. Second, the fact that the annual export quota of 100 live animals is not based on formal stock assessments could lead to overexploitation of dolphin species in Solomon Islands waters (Oremus et al. 2011, Reeves and Brownell Jr 2009). In response to such criticism, the government lowered the limit to 40, and then placed a complete ban on the export of live dolphins effective 2012.

Formal studies of both the degree of abundance and distribution of dolphins in central Solomon Islands were performed over the period 2009–2011 (Oremus et al. 2011). These studies concluded that the sustainable rate of extraction for *Tursiops aduncus* (the Indo-Pacific bottlenose dolphin primarily targeted for export) from the waters of southwestern Guadalcanal and Florida Islands was fewer than one dolphin every 5 years. For south Santa Isabel and west Malaita, the corresponding limit was fewer than two dolphins every 5 years. More specifically, Oremus et al. (2013) concluded that "Based on these calculations, the authorized export quota (50 dolphins per year) and the effective number of dolphins exported since 2003 (average 12 dolphins per year) are unsustainable if concentrated on one or few local populations, as it has been the case so far." (Oremus et al. 2013). This report also recommended that more surveys and monitoring be performed to guide future management actions.

Whales

Leary and Pita (2000) suggest that eight species of whales may be present in Solomon Islands waters, and that three other species have been reported as sighted: *Kogia* sp. (Shimada and Pastene 1995, Goto et al. 1997), *Balaenoptera brydei* (Kahn 2006), and *Balaenoptera omurai.* Whales are currently not hunted in Solomon Islands, and no whale-watching programs currently exist. Unfortunately, the amount of information concerning their ecology and interaction with fisheries is scant, since only a few such surveys have been performed (Shimada and Pastene 1995, Goto et al. 1997, Shimada and Miyashita 2001, Kahn 2006, Oremus et al. 2011). What is known is that Solomon Islands is an important migration corridor for small and large cetaceans (Kahn 2006). A greater degree of understanding of their ecology in Solomon Islands waters would thus help form relevant conservation and management plans.

Dugong

The dugong is a large herbivorous mammal that inhabits Solomon Islands waters and feeds almost exclusively on seagrass. The primary species in Solomon Islands, *Dugong dugon* is thus mainly present in areas where seagrass beds abound. Dugongs are hunted for purposes of direct consumption in many parts of Solomon Islands. While no studies on the distribution and ecology of dugongs have as yet been conducted in Solomon Islands, the anecdotal reports that are available indicate that they may be overexploited in some locations. However, in late 2010 and early 2011, an interview survey was conducted in the coastal communities of Guadalcanal, Isabel, and Makira to (i) determine locations where dugongs have been sighted, (ii) gather local knowledge of dugongs, and (iii) gain an overall indication of their status. Formal studies of dugongs to specifically inform the formulation of conservation and management initiatives would greatly help protect this species.

Excessive nutrients and other pollution issues

Domestic pollution associated with excessive nutrients continues to plague Solomon Islands (Sulu et al. 2000) as sewage treatment plants do not exist, even in Honiara or other semi-urban centers. In Honiara, at least 75% of all sewage still flows through a piped collection system directly into the sea without treatment. While no studies have quantified the degree of industrial pollution in Solomon Islands, the Ranadi Industrial site in Honiara, shipping slipways—in Tulagi, Aviavi, Taroniara in Nggela, and Liapari in Vela Lavella—and the fish processing factory at Noro in New Georgia probably contribute significantly to marine pollution.

In addition to marine pollution from the release of excessive nutrients, both logging operations and industrial plantations release significant amounts of nutrients and sediments into the marine environment. Despite Solomon Islands' relatively small geographic size, the country is home to extensive logging operations. For example, logging occurs in Choiseul, Guadalcanal, Kolombagara, Makira, Malaita, New Georgia, Nggela, and Vella Lavella. Despite the substantial contribution of logging and industrial plantations to national income, these activities negatively impact Solomon Islands' coral reef systems. Such impacts include a phase shift to an algae-dominated ecosystem, and smothering of corals by sediment runoff from logged catchments. However, in light of their significant contribution to national income, the pollution released by logging and industrial plantation activities is unlikely to abate any time soon.

The few existing studies on the effects of logging report a decline in benthic communities at the mouths of rivers downstream from logged catchments (Morrisey et al. 2003). Further, anecdotal and historical evidence based on trace metal analysis of *Porites* corals indicates that changes in the water quality of coral reef systems within Marovo lagoon coincided with the onset of logging in adjacent catchment areas (Albert 2007). Further, changes in water quality coupled with low levels of herbivory due to intense fishing of herbivorous fishes have resulted in a shift to an algae-dominated coral reef system in some parts of the lagoon. Moreover, clear felling in catchments could ultimately result in a complete transition of the entire Marovo lagoon to an algae-dominated system. While no studies on the effects of logging in other parts of Solomon Islands exist, the results of such studies would possibly identify effects similar to those reported by Morrisey et al. (2003) and Albert (2007) for Kolombangara and Marovo lagoons, respectively.

Tourism development projects in coastal areas

Relative to other Coral Triangle countries, tourism in Solomon Islands is limited. Apart from the six major hotels in Honiara, most tourism accommodation is located in provincial centers or rural areas, and is of relatively small scale, in that its capacity ranges from 4 to 20 persons in rural areas, and 6 to 50 persons in provincial centers.

Currently, no large-scale, tourism-related coastal development exists. However, plans do exist for large-scale tourism development in Anuha (Nggela) and Kennedy Island in Western Province. A growing concern with regard to coastal development is the mining of coral. Corals, predominantly *Porites*, are mined from reefs and then used to build coastal sea walls, seaward extensions of land, and artificial islands. Coral mining is likely to increasingly result in negative environmental impacts as coastal dwellers adapt to sea-level rise and coastal erosion

by constructing sea walls. Unfortunately, current regulations restricting the mining of corals continue to be ignored, and thus remain unenforced. In the absence of enforcement of even existing regulations, the only certain limit to coral mining will be the eventual dearth of corals on accessible reefs.

Natural disasters

Solomon Islands is geographically located on the "Pacific Ring of Fire" as well as in the "warm pool" region of the South Pacific Convergence Zone. As a result, the country is prone to natural disasters that arise from movement of the tectonic plate on which it sits, as well as its location in the South Pacific Convergence Zone. These disasters include volcanic eruptions, earthquakes, tsunamis, and tropical cyclones. Solomon Islands is home to both dormant and active volcanoes, the latter being Kavachi submarine volcano south of Vangunu in Eastern New Georgia, and Tinakula volcano far to the east in the Santa Cruz Group. Though technically classified as dormant, many of the country's volcanoes that have not erupted recently still emit fumes. These include Paraso volcano on Vella Lavella, Savo Island volcano that sits between Nggela and Guadalcanal, and Simbo volcano on Nusa Simbo Island. Fortunately, none of these volcanoes have been active enough to cause a major natural disaster.

Due to the country's location on the Pacific Ring of Fire, earth tremors and earthquakes frequently occur. However, these do not always cause natural disasters of any significant scale. That said, a recent major tectonic plate movement resulted in a mid-ocean earthquake that triggered a tsunami on 2 April 2007.[8] In addition to the tsunami that caused significant loss of life and property (McAdoo et al. 2008), the earthquake resulted in interior and coastal landslides, and an uplift of coral reefs of up to 3 meters in some locations that caused significant damage to corals (Albert et al. 2007).

In Solomon Islands, tropical cyclones occur annually. Due to their geographic location, Bellona, Makira, Rennell, and the southern parts of Guadalcanal are particularly vulnerable to cyclonic impacts. During the 1969–1970 and 2009–2010 cyclone seasons, 41 cyclones passed within 400 km of Honiara, with one cyclone occurring per season on average (Abbs et al. 2011).

Historically, tropical cyclones have been more frequent during El Niño years, with 1.3 cyclones occurring per season compared to an average of 0.6 cyclones occurring during La Niña years, and 0.9 cyclones occurring during neutral seasons (Abbs et al. 2011). Fortunately, current research and analysis of available data suggest that fewer tropical cyclones will occur in the South Pacific in future years. That said, the average intensity of tropical cyclones is forecast to increase (Abbs et al. 2011, Australian Bureau of Meteorology and Commonwealth Scientific and Industrial Research Organisation [CSIRO] 2011a). The impacts of tropical cyclones vary widely, with low-intensity cyclones producing no noticeable damage. However, intense cyclones produce significant damage from wind shear, heavy rainfall, and storm surge. While tropical cyclones occur frequently in Solomon Islands and impact the country's coral reef systems, their effects are usually not monitored; thus, there is little documentation concerning their impact on coral reefs. At least theoretically, it could be argued that tropical cyclones are frequent natural disturbances, and that they therefore could have influenced the physical and biological

[8] The epicenter of this earthquake was 40 km south–southeast of Gizo, at a depth of 10 km.

structures of the country's reef ecosystems, including their resilience to such events. However, the contrary may be true of intense cyclones.

Rehabilitation, Restoration, and Restocking

The Foundation for the Peoples of the South Pacific International (FSPI) has implemented ecosystem rehabilitation initiatives in some communities in Langalanga lagoon in Malaita. Their first project implemented in 2003–2004 rehabilitated coral reefs destroyed by dynamite and other destructive fishing practices. While observed coral growth rates at the Laulasi and Gwaunaofa project sites were judged to be good, coral growth at other project sites was hampered by poor water quality (Hugo Tafea, personal communication, 2012). As FSPI completed this project in 2004, no further updates regarding coral growth rates at project sites are available.

The Loa mangrove rehabilitation project was the second coral reef rehabilitation project implemented at Langalanga lagoon. This project was initially begun by a Kalagwata community member called Tisa in 2001. Tisa initially planted cocoa (*Theobroma cacao*) in one section of a wetland area devoid of mangroves as a result of overharvesting. As these cocoa plants died, Tisa replaced them with the mangrove species *Bruguiera gymnorrhiza*. This mangrove species is particularly important to the local community as its propagules are consumed as food, and its wood is used in house construction and as firewood. Tisa's mangrove culture efforts were successful in that several years later, the mangroves he planted benefited his family through the yielded seeds that could be used as food, as well as pruned branches that could be used as firewood. Other community members followed his example and began to replant areas devoid of mangroves. This replanting of overharvested mangrove areas expanded rapidly to other communities. As of 2007, the communities of Dawn Break, Kalagwata, Kukuli, and Loa had all begun replanting overharvested mangrove areas. Following these community-level initiatives, over the period 2007–2008, FSPI applied for financial assistance from the European Union (EU) Sustainable Forest Project to expand mangrove replanting. While the EU responded by providing $3,900 for the construction of an office and information center, disagreements between the EU and the community regarding funding arrangements resulted in cessation of EU support in 2008. The WorldFish Center also contributed technical support and training to the project (Collin Gereniu, personal communication, 2012). As of 2009, 7.75 ha of mangroves had been planted, with another 12.25 ha remaining to be planted.

During the 1990s, the Government of Solomon Islands established a coastal aquaculture research facility at Aruligo in Guadalcanal with assistance from the International Center for Living Aquatic Resources Management (ICLARM, now renamed the WorldFish Center). The objective of this facility was to rear giant clams (*Tridacna gigas*) and sea cucumbers (*Holothuria scabra*) in captivity. These giant clams and sea cucumber were then to be used for restocking coral reefs and supporting the aquarium trade and aquaculture industry. This effort was successful in that giant clams and sea cucumbers were successfully reared, and some reefs were restocked. This same facility was also used by a project funded by the Overseas Fisheries Cooperation Foundation of Japan, whose ultimate purpose was restocking of trochus and green snail. However, in the face of the ethnic conflicts of 2000–2003, these initiatives ceased operation as a result of closure of the facility. There are currently no restocking initiatives.

Emerging Issues in Marine Resource Use

Transboundary issues

Solomon Islands borders Australia, Fiji, New Caledonia, PNG, and Vanuatu. Its nearest border is PNG to the northwest, where citizens of both countries share kinship ties. This is particularly true of some communities in the Shortland Islands (which belong to Solomon Islands) and Bougainville (which belongs to PNG), as well as Lord Howe and Pelau atolls (Solomon Islands) and Nukumanu and Tasman Islands (PNG). The interaction between kinship ties across national borders raises several resource management challenges.

First, prohibited commodities are transported for resale across this border. More specifically, sea cucumbers—which are closed to exploitation—are harvested on the Solomon Islands side (Lord Howe and Pelau islands) of the border and then transported to Tasman and Nukumanu, and then on to Kavieng and Rabaul on the PNG side of the border. The smuggled sea cucumbers are then sold in Asian markets. Similarly, during the period preceding closure of the sea cucumber fishery, anecdotal reports indicated that trochus and sea cucumbers harvested in Bougainville were being transported to the Solomon Islands side of the border.

Thus, closing this illegal trade in endangered species will require harmonizing closures of prohibited species, and co-management by the countries concerned. However, achieving such harmonization is usually difficult, given differences in national priorities and resource management regimes.

Another transborder trade issue concerns migratory species. For example, turtles may nest in one national maritime zone and forage in others (Benson et al. 2011). Lack of harmonization of species closure arrangements and management by the countries concerned makes protection and management of these species difficult.

Aquaculture

As mentioned previously, Solomon Islands aquaculture operations are currently limited in scale. As a result, these operations result in few negative environmental impacts. However, given the projected future shortfall in the supply of fish relative to demand, aquaculture will likely fill this demand–supply gap (Bell et al. 2009). This implies significant increases in both the scale and intensity of aquaculture over a relatively short period.

Together with the WorldFish Center, MFMR is currently performing studies to determine the feasibility of culturing the locally occurring species *Chanos chanos.* The probability of success in culturing this species is high, given that *Chanos chanos* is a popular cultured species in Indonesia, the Philippines, and other Southeast Asian countries. It is also popular in Taipei,China. While *Chanos chanos* can survive in freshwater and seawater, it can only reproduce in water with a salinity of 33–35 parts per thousand. As a result, it can be cultured in both land-based dugout freshwater ponds and in cages in the marine environment. While operational measures can prevent negative environmental impacts resulting from the culture of *Chanos chanos*, regulations requiring that such measures be taken should be put in place well before large-scale culturing of said species begins.

Ultimately, aquaculture has the potential to result in any of the negative environmental impacts listed below:

(i) Heavy consumption of plankton or benthos by caged or enclosed farmed organisms reduces the supply of food required by adjacent natural communities.
(ii) If aquaculture pens or cages are located too close to one another, pathogens and parasites can easily spread from one pen or cage to another.
(iii) Both animal waste and unconsumed feed can potentially result in eutrophication (Munro 1994).
(iv) Algal blooms that increase biochemical oxygen demand can result from extensive aquaculture operations.

Many of the problems listed above have already occurred in the Philippines, as *Chanos chanos* cage culture is currently unregulated and uncontrolled in that country (Marine Science Institute, University of the Philippines 2010).

In a similar vein, before allowing exotic species to be cultured in aquaculture pens or cages, a comprehensive risk assessment should be performed to ensure against harm being done to native aquatic species, as well as occurrence of any undesired ecological consequences.

Harmful algal blooms

As no research regarding harmful algal blooms currently exists in Solomon Islands, the extent of this problem is undocumented. That said, complaints relating to headaches, body aches, general weakness that lasts for several days, delusions, and strange dreams abound following the consumption of fish or shellfish collected from certain locations during particular periods of the year (Duke et al. 2007, Albert et al. 2011). These symptoms are possibly caused by blooms of algae such as the toxic red tide dinoflagellate species *Ceratium dens, Brachydinium capitatum* (Duke et al. 2007), and *Pyrodinium bahamense* (Albert et al. 2011), all of which are present in Solomon Islands.

Similarly, in June 2011, a large fish kill occurred in Marovo lagoon (Albert et al. 2011, Albert and Moore 2011). This fish kill was associated with an algal bloom and consequent deoxygenation of seawater, which although a natural event was possibly exacerbated by multiple local (i.e., increased nutrient input) and global (i.e., climate change) environmental pressures (Albert et al. 2011). One possible factor contributing to this fish kill was the blooming of the toxic diatom *Psuedo-nitzschia.* According to Albert et al. (2011), there are no records of *Psuedo-nitzschia* being naturally present in Solomon Islands. As a result, such algal blooms may be caused by discharge of ballast water from logging ships, a practice that has only recently begun. However, absence of baseline data regarding plankton in Solomon Islands makes verification of this hypothesis difficult.

Ballast water, hull fouling, and marine invasive species

Solomon Islands ports do not receive the significant volumes of ballast water that are discharged in large ports such as Chesapeake Bay, Melbourne, or San Francisco. As Solomon Islands ports are quite small, most visiting ships are small- to medium-sized fishing boats, reefers, container vessels, and occasional luxury liners. However, the log-exporting ports of Guadalcanal, Malaita,

Makira, and Western Solomon Islands handle significant amounts of cargo. While there are no estimates of the amount of ballast water discharged at these ports, most log carriers arrive heavily ballasted before on-loading logs and timber. As a result, the freight volumes handled at these ports are sufficient to give cause for concern.

Many vessels operating in Solomon Islands are fishing boats with home ports in Japan; the Republic of Korea; the Philippines; and Taipei,China, as well as other parts of Asia. Some vessels arrive with fouled hulls, and remain in Solomon Islands for long periods. For example, several vessels from the Republic of Korea are semi-residents at the port in Honiara. Further, since the home ports of many of these vessels are located in subtropical and tropical climes, the species that cling to their hulls are likely to find the water temperatures of Solomon Islands compatible with those of their respective home ports. Unfortunately, the number of species introduced to Solomon Islands waters by this means is unknown.

Of greater concern is the number of species that may be introduced when ships traveling from Asia or North America to Australasia make what is known as "mid-ocean ballast water exchanges." While it is a common perception that these mid- or deep-ocean exchanges are made hundreds of miles from any coast, this is generally not the case in the South Pacific. In fact, both the western and central Pacific are home to numerous islands. As a result, the only empty portions of the Pacific lie far to the east and north (e.g., north of Hawaii) and far southeast of New Zealand's Chatham Islands.

Most of Australia's and New Zealand's trade is with Asia. As a result, the ships that ply these routes travel through Indonesia, the Philippines, and the Melanesian Islands (e.g., the Bismarck Archipelago, New Caledonia, Solomon Islands, and Vanuatu). These islands semi-enclose several seas such as the Bismarck Sea, the Solomon Sea, the Coral Sea, and the Arafura Sea that lies between Australia and New Guinea. Ships traveling from Japan to New Zealand and Australian ports, for example, often travel south through Indonesia, Malaysia, and Philippine waters, often within sight of land. In Solomon Islands, some of the large bulk carriers travel through the double chain of islands that during World War II was referred to as the "Slot". Mid-ocean exchanges are often made in these seas, if for no other reason because the surrounding islands provide protection from the full force of open ocean swells. Thus, much of the ballast water discharged from vessels originating in the People's Republic of China, Japan, the Republic of Korea, and other Asian countries is exchanged for tropical water in a manner that allows it to end up in Solomon Islands waters.

Thus far, Solomon Islands appears to have had no spectacular outbreaks of foreign aquatic species in its ports. This is particularly true when compared to those recorded in Australasia, Europe, and North America. Nevertheless, in the Solomon Islands context, erring on the side of caution demands that port surveys be conducted at the country's major ports. Such an exercise typically makes use of the services of marine taxonomists. Unfortunately, marine taxonomy has been a casualty of the restructuring and semi-privatization of research organizations in the industrialized countries (e.g., Australia and New Zealand) over the past 30 years. Ironically, this restructuring occurred just before the period when monitoring biodiversity suddenly became fashionable in funding circles.

Fortunately, few of the islands that make up the country have a significant continental shelf, as many of these islands are simply tips of submarine mountains. This in itself may reduce the risk of foreign species becoming established in Solomon Islands waters. Further, much of the ballast water that is exchanged in areas adjacent to Solomon Islands probably comes from temperate Asian waters, which means that the temperate species potentially present in the discharged ballast may not survive the higher temperatures of tropical waters.

However, ballast may be taken on in numerous ports, some of which are subtropical or, in the case of countries such as Singapore, fully tropical. Other ships discharge ballast taken on in tropical and subtropical ports in the Indian Ocean or the Arabian Gulf. These ships are likely vectors for spreading tropical and subtropical species from subtropical regions north of the equator to the south, from the Indian Ocean to the Pacific, and eventually to Solomon Islands. If this issue remains unaddressed, events such as the June 2011 fish kill in Marovo could result. The Shipping Act 1998 that prohibits pollution of the marine environment should be reviewed in this light, and necessary clauses inserted into the legislation that address issues relating to discharge of ballast water and hull-fouling. Compliance is likely be a major issue in this regard, as it may be costly to obtain the evidence necessary for taking legal action against offenders.

Climate change impacts

Trends in the country's climate parameters are consistent with those generally observed in the Pacific (MECM 2008). Both air and sea-surface temperatures have gradually increased over the entire period 1951–2009. Since the 1970s, the sea-surface warming rate has remained relatively constant at 0.12°C per decade. Similarly, the annual rate of sea-level rise since 1993 has remained constant about 8 millimeters, a rate higher than the global average of 3.2 millimeters (Australian Bureau of Meteorology and CSIRO 2011b). In contrast, annual rainfall levels in Solomon Islands have fallen over the entire period 1950–2005, a trend that holds the prospect of long dry spells during the warm phase of the El Niño–Southern Oscillations (MECM 2008, Australian Bureau of Meteorology and CSIRO 2011b).

Current climatic trends do not bode well for Solomon Islands. Further, the impacts of climate change are beginning to appear in some locations in the country. For example, some small low-lying islands have simply disappeared, saltwater has intruded into freshwater lenses, and some coastlines and coastal vegetation have become inundated with seawater (MECM 2008). Further, projections of future climate change impacts remain pessimistic (Brokovich and Schwarz 2010). If current climate change forecasts are fulfilled, food production will be negatively impacted (Ahmed et al. 2011) as will biodiversity (Brokovich and Schwarz 2010), fisheries, and aquaculture (Bell et al. 2011, Pickering et al. 2011, Pratchett et al. 2011). Bell et al. (2011) forecast a decline in tuna catches in the western Pacific with consequent increases in the eastern Pacific, as tuna move eastward in the face of climate change, thus negatively impacting Solomon Islands tuna catches. Moderate increases in temperature and changes in water circulation are also forecast to negatively impact the reproductive output, development, and survival of corals, fish, and other species important to Solomon Islands coastal fisheries (Pratchett et al. 2011). All these changes would significantly impact food security, opportunities for income generation, and even the amount of revenue available to the government.

Ocean acidification

Ocean acidification is caused by the uptake of excess carbon dioxide (from emissions) by the world's oceans. This results in formation of carbonic acid that causes the ocean pH to fall. This lower oceanic pH in turn reduces the availability of dissolved carbonate ions that many marine calcifying organisms—corals, other invertebrates, and coralline algae in particular—use to build their shells or skeletons (Pratchett et al. 2011). Optimum coral growth and healthy reef systems require aragonite (calcium carbonate) saturation greater than 4.0 (Australian Bureau of Meteorology and CSIRO 2011b). In Solomon Islands, the saturation state has declined from approximately 4.5 in the late 18th century to an observed value of 3.9 in 2000. The prospects for the country's coral reefs are thus gloomy.

Coral bleaching and coral diseases

Coral bleaching and diseases are emerging issues in Solomon Islands. Coral bleaching is normally associated with elevated seawater temperatures, such as those that occur during El Niño periods, while coral diseases are normally associated with degraded water quality. The onset of coral diseases may also be associated with—or following—coral bleaching episodes. Although there are currently no reports of significant coral bleaching in Solomon Islands, anecdotal reports of small-scale bleaching in many parts of the country have occurred during warm periods. Two studies on coral diseases in Solomon Islands were conducted, one in Marovo by Albert et al. (2010) and the other in Roviana lagoon by Albert et al. (2012). Coral diseases that appeared in Marovo included black band disease, brown band disease, white plague, white patch, white syndrome, and an unnamed syndrome that affects the edges of plating corals (Albert et al. 2010). Coral diseases that occurred in Roviana lagoon were mainly the white syndrome and the unnamed syndrome first reported in Marovo by Albert et al. (2010) that affected *Porites* rather than plating corals as in Roviana lagoon.

Only one major outbreak of coral disease has been reported. This report relates to a location in Marovo known as Tibara where predation by corallivorous snails initiated widespread coral diseases, including white band and black band disease on *Acropora* and *Porites* stands. According to Albert et al. (2010), disease-like symptoms and predation suggest that disturbances to the ecological system at Tibara may have lowered the resistance of the coral there to predators. Alternatively, an outbreak of corallivores—most likely snails—may have occurred. These organisms feed at the base of the coral. This feeding in turn causes lesions that ultimately destroy far greater amounts of coral than those that are actually consumed by the feeding itself.

The most comprehensive assessment of coral bleaching in Solomon Islands thus far was jointly conducted by The Nature Conservancy, the Worldwide Fund for Nature, and partner organizations in 2004 (Green et al. 2006). All subsequent surveys of coral bleaching and coral diseases have been one-off studies. Monitoring more locations over consistent time periods is necessary to achieve a better understanding of the frequency and extent of coral bleaching and coral diseases in Solomon Islands. Unfortunately, this requires financial and human resources that are generally unavailable, particularly in the face of so many competing environmental and conservation issues.

National Plan of Action Initiatives and Future Plans

The Solomon Islands National Plan of Action (NPOA) for the Coral Triangle Initiative (CTI) is the primary document guiding management of the country's coral reefs. To ensure that the NPOA incorporated both local circumstances and the well-being of the entire country, its formulation drew on input from a wide range of stakeholders at all levels of governance. This included individual residents of local communities, community-based groups, NGOs, and national government agencies. A number of other documents that relate to management of the country's marine resource complement the NPOA (MFMR 2010). These documents include the country's strategy for management of inshore fisheries and marine resources (Ministry of Fisheries and Marine Resources 2010).

The Solomon Islands NPOA identifies five goals for the country's marine resources:

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 CTI principles and guidelines. Further, each of the five goals set out above includes appropriate strategies and quantitative targets.

For example, the priority seascapes identified under Goal 1 above comprise large-scale geographies that have been prioritized for both 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. Likewise, the effective management of MPAs included under Goal 3 is to include community-based resource utilization and management.

This section of the report describes the formulation of the Solomon Islands NPOA, as well as the progress the country has achieved in fulfilling the goals it embodies.

Formulation of the Solomon Islands NPOA

In June 2008, a national CTI technical committee was constituted to formulate the NPOA. This technical committee was composed of relevant government agencies and NGO partners. More specifically, the government agencies included in the CTI technical committee's membership included the

(i) Ministry of Environment, Climate Change, Disaster Management and Meteorology (formerly MECM);
(ii) Ministry of Fisheries and Marine Resources (MFMR);
(iii) Ministry of National Planning and Aid Coordination; and the
(iv) Ministry of Foreign Affairs and Trade.

The NGO partners included in the technical committee's membership included

(i) The Nature Conservancy (TNC);
(ii) Worldwide Fund for Nature (WWF, formerly the World Wildlife Fund);
(iii) Foundation for the Peoples of the South Pacific International [FSPI]; and
(iv) WorldFish Center (formally the International Center for Living Aquatic Resources Management).

Using the draft CTI Regional Plan of Action as a guide, the team identified former, current, and future Solomon Islands marine resource initiatives that could form the foundation for the Solomon Islands NPOA. Using these former, current, and future initiatives as a starting point, the technical committee then formulated an indicative list of marine resource initiatives to be undertaken by Solomon Islands in support of the five goals of the NPOA identified above. Following the adoption of the CTI Regional Action Plan in May 2009 by the CTI Leaders Summit, this indicative list of initiatives formed the foundation of the Solomon Islands NPOA.

With technical support from the United States (US) CTI Support Program, the country's lead ministries for marine resources (MECM and MFMR) then reexamined this indicative list of initiatives, and considered all national priority areas, objectives, and specific initiatives that related directly to CTI objectives.

Then in mid-2009, a Visionary National Stakeholder Workshop was convened to obtain the input of all stakeholders with an interest in the Solomon Islands marine resource. This was an important step in formulating the country's NPOA, as it laid the foundation for the participation of these stakeholders in implementing the NPOA. The output of this workshop included the recommendations listed directly below (CTI Visionary National Stakeholder Workshop Draft Report 2009):

(i) MECM and MFMR were to be the focal points for implementing the CTI.
(ii) A Multistakeholder National Coordination Committee was to be established.
(iii) A CTI Unit was to be established within MECM.
(iv) The draft NPOA was to be formally endorsed by the Solomon Islands Cabinet.

Officially endorsed in early 2010, the 5-year NPOA outlines a national strategy for implementing the CTI in Solomon Islands. This implementation strategy includes a community-based approach to resource management, necessary changes in national legislation and policy, appropriate

management of data and information relating to marine resources, and education and awareness raising relevant to its long-term management (MECM and MFMR 2010). Finally, the officially endorsed version of the NPOA specifies that MECDM (formerly MECM) and MFMR would remain the lead agencies for implementing the Solomon Islands NPOA.

Goal 1: Designation and Effective Management of Priority Seascapes

In fulfilling Goal 1 of the Solomon Islands NPOA, the government designated the Bismarck-Solomon Seas Ecoregion (BSSE) as a priority seascape. The BSSE describes a marine expanse of approximately 2 million km^2 that extends from the Vogel (Doberai) Peninsula of Papua Province of Indonesia in the west, across the Admiralty and Bismarck archipelagos of PNG in an eastward direction, to Makira Island (Solomon Islands) in the east.

One reason for designating the BSSE as a priority seascape is that it is home to the critically endangered Western Pacific leatherback turtle (*Dermochelys coriacea*) (International Union for the Conservation of Nature [IUCN] 2006). To ensure survival of this turtle species, a Tri-Nations Agreement on Leatherback Turtle Conservation in the Bismarck-Solomon Seas Ecoregion was concluded in 2006. This document was essentially a memorandum of understanding that declared a transboundary partnership for conservation of the leatherback turtle. While seemingly a small step toward preservation of a critically endangered species, this partnership enabled formulation of a regional leatherback turtle action plan that allows for sharing of research, data, and information relating to conservation of the leatherback turtle. As a complementary initiative, the Solomon Islands government has plans to establish MPA networks in habitats critical to supporting conservation of this critically endangered species.

While the country has made valiant efforts to align specific initiatives with the regional leatherback turtle action plan referred to above, implementation of the regional plan has been ineffective. This is largely due to the fact that regional implementation of action plans of this type requires high-level political initiatives of national government, cooperation by groups at the local community level, and often third-party interventions by NGOs, academic institutions, or international conventions. Due to these constraints, coordination of implementation efforts has been ad hoc, and funding allocations by national governments and other stakeholders alike have been limited. In short, implementation of plans of this type ultimately depends on participation by multiple authorities at various levels and numerous layers of users (Horokou, personal communication, 2011).

One of the many benefits of the CTI is that it provides an established framework for incorporating initiatives at both the national and regional levels that support achievement of its objectives. This was certainly true in the case of the BSSE Initiative.

Geographically, the BSSE Initiative encompasses both the Admiralty and Bismarck archipelagos, as well as the northern coast of mainland PNG. The primary ecological importance of this oceanic expanse is that it is home to some of the few tropical marine ecosystems that remain relatively unaffected by human activity. As a regional initiative attempting to coordinate actions in support of ecological objectives that transcend national boundaries, the BSSE Initiative has not

been immune from the constraints of such programs discussed in the paragraphs immediately above. Nevertheless, even the mere existence of the CTI provided a basis for revitalizing the BSSE Initiative by recasting it into the context of broader CTI goals.

For this purpose, Solomon Islands engaged both Indonesia and PNG in bilateral discussions in 2009 and 2010. The purpose of these meetings was to discuss options for expanding the existing BSSE Tri-Nation Agreement. With support from the Solomon Islands Ministry of Foreign Affairs and External Trade, the CTI agenda was included in bilateral meetings with PNG in Bougainville in 2009 and in Gizo, Solomon Islands in 2010. A bilateral meeting between Solomon Islands and Indonesia was likewise convened for this same purpose in Jakarta in 2010. All these meetings reaffirmed the Bismarck-Solomon Seas Ecoregion as a potential priority seascape.

While central to the present discussion, the CTI is not the only initiative that supports sustainable management of the marine resources in the Coral Triangle. For example, a parallel regional initiative named *Strengthening Coastal and Marine Resources Management in the Coral Triangle of the Pacific* is supported by the Global Environment Facility and ADB. Other complementary programs are likewise supported by the Secretariat of the Pacific Regional Environment Programme (SPREP), the Secretariat of the Pacific Community, the Forum Fisheries Agency, and the Locally Managed Marine Area (LMMA) Network. All of the above are regional initiatives that address issues relating to management of marine and coastal resources, as well as the negative impacts of climate change in both Solomon Islands and the Coral Triangle.

In addition to regional initiatives such as those referred to above, a broad array of projects address marine and coastal resource issues in Solomon Islands at the national level. These include projects funded by Australian Aid, the EU, the Japan International Cooperation Agency (JICA), and the United Nations Development Programme (UNDP). The objectives of these national-level initiatives include (i) mitigating mismanagement of the marine resource regardless of its cause; (ii) providing support to changes in policy, legislation, and regulations that promote environmentally responsible marine resource management; (iii) establishing or strengthening environmental education and awareness programs; and (iv) improving waste management in a way that protects the oceanic resource and its ecosystems from unsustainable resource use.

Further, a number of development initiatives also complement and facilitate achievement of CTI objectives through programs that support sustainable livelihood strategies for residents of coastal communities, improve management practices as these relate to the marine resource, and build resilience or promote adaptation to the negative impacts of climate change. Examples of such programs include Mekem Strong Solomon Islands Fisheries, Mangrove Ecosystems for Climate Change Adaptation and Livelihoods, and Strengthening Environment Management and Reducing the Impact of Climate Change. While the initiatives referred to above are welcome additions to marine resource management that support achievement of CTI objectives, the degree of coordination, sharing, learning, and formation of partnerships among such programs and projects remains below optimal levels.

Finally, Solomon Islands could potentially join seascape initiatives that complement CTI objectives. Examples include the Coral Seas Programme sponsored by Australia, and initiatives that support environmental protection of the seascapes that lie between Solomon Islands and Vanuatu. With regard to the latter, the *Conservation International Seascapes Guidelines 2011* could potentially guide such participation.

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

Solomon Islands has no policies or regulations that specifically promote ecosystem approach to fisheries management (EAFM). However, many of its policies, legislation, and regulations that address marine resource management issues already incorporate or reflect EAFM principles. Examples include the Fisheries Act 1998, a broad array of fisheries regulations, and management plans currently in force that address specific marine resource management issues such as the Live Reef Food Fish Trade Management Plan and the Bêche-de-mer Management Plan. Further, all provincial ordinances that address integrated coastal resource management and EAFM are currently being reviewed. As a result, some provinces have already begun formulating fisheries ordinances that incorporate EAFM principles.

Further, a number of NGOs are assisting national- and regional-level projects by training residents of local communities on EAFM principles to enable integration of EAFM principles into community-based resource management (CBRM) plans. These NGOs further support these projects by assisting communities receptive to CBRM formulate coastal resource management guidelines based on EAFM principles. Finally, NGOs conduct environmental awareness programs that introduce residents of local communities to EAFM principles, thus facilitating eventual adoption of CBRM by these communities.

For example, the "ridges-to-reefs approach" sponsored by The Nature Conservancy is being piloted in Malaita Province to underscore the link between terrestrial and marine environments. Under this pilot program, environmental threats to terrestrial and marine ecosystems in Malaita have been mapped and potential conservation sites identified. These include sites of cultural, environmental, and socioeconomic importance. In Isabel, a pilot program for implementing CBRM is encouraging residents of the communities concerned to take ultimate responsibility for ensuring sustainable use of all resources, particularly those that comprise their traditional fishing grounds. MFMR is improving its capacity to assess, monitor, and sustainably manage species of fish in danger of overexploitation, such as the iconic bumphead parrotfish.

The only EAFM policy currently being developed at the national level is that relating to the Solomon Islands tuna fishery (Pacific Islands Forum Fisheries Agency and MFMR 2011). In parallel with formulation of this policy, the Fisheries Act 1998 is to be revised in a manner that incorporates EAFM principles.

Goal 3: Establishment and Effective Management of Marine Protected Areas

In Solomon Islands, the use of locally managed marine areas (LMMAs) is commonplace. According to Hugh Govan (personal communication, 2012), the LMMA approach is widely accepted in the Solomon Islands, as it builds on local and traditional approaches to resource management and emphasizes the likely benefits of LLMAs. These include recovery of natural resources, improved food security, improved governance, and access to information and services. Govan adds that communities prefer to manage their own resources, as this allows them to directly reap the benefits of doing so.

The fact that the Solomon Islands NPOA recognizes customary ownership of marine resources has profound implications for their management, as well as the division of the benefits derived from them. More specifically, recognition of customary ownership of marine resources implies that the owners of such resources must be the primary beneficiaries of the benefits derived from them, and that the owners themselves should be provided with the capacity to manage these resources, and to adapt to looming threats such as the negative impacts of climate change (Ministry of Environment Conservation and Meteorology and MFMR 2010). The discussion immediately below highlights the status of LMMAs in Solomon Islands, and summarizes the progress achieved thus far in marine resource management in this regard.

Most Solomon Islands LMMAs are established with the support of partner NGOs, or academic or government entities. In 2003, the Solomon Islands Locally Managed Marine Area (SILMMA) Network was established to coordinate management of LLMAs. SILMMA is a diverse group that shares the common objective of improving management of Solomon Islands fisheries (SILMMA Network 2009). Its membership includes environmental and resource management practitioners drawn from NGOs, government, and local communities, and in some cases project staff. In 2008, management of LLMAs was placed under MFMR authority.

Establishment of SILMMA constituted an important step in marine resource management not only in Solomon Islands but also in the entire Coral Triangle. As a result, the CTI identified SILMMA as the coordinating point for all MPA- and LMMA-related activities. Table 9 summarizes the initiatives that have been undertaken for improving MPA and LLMA management capacity within the Coral Triangle.

Since most LMMAs are supported by NGOs or academic institutions, their systems for monitoring and improving LMMA management vary. Table 10 summarizes the initiatives that formulated protocols and guidelines for SILMMA for standardizing monitoring and data management systems.

With support from the Coral Triangle Pacific project and other similar initiatives, MFMR intends to both expand the number of LMMAs active in Solomon Islands and strengthen their respective management capacities.

Goal 4: Application of Climate Change Adaptation Measures

The global community has

(i) accepted the existence of climate change,
(ii) recognized that its source is human activity that specifically includes burning of fossil fuels and exploitation of terrestrial and marine resources at unsustainable rates, and
(iii) acknowledged that climate change has serious socioeconomic and physical consequences for numerous countries, the least-developed tropical countries such as Solomon Islands in particular due to their significant degree of dependence on coral reefs and subsistence fisheries (Ministry of Environment Conservation and Meteorology 2008).

Table 9 **Coral Triangle Initiatives for Improving the Management Capacity of Marine Protected Areas and Locally Managed Marine Areas**

Type of Initiative	Location	Initiative	No. of Persons Trained or Attendees	Funding Agency
Regional Exchange	Phuket, Thailand	Marine Protected Area Regional Exchange that focused on the design and operation of MPA networks and systems	4	USAID
Regional Exchange	Batangas, Philippines	Regional Exchange/Workshop on Monitoring and Evaluation for Improving MPA Management Effectiveness in Coral Triangle countries	4	USAID
Regional Exchange	Denpasar, Indonesia	Regional Exchange and Workshop in Support of the CTI	3	USAID
Regional	Nadi, Fiji	Locally Managed Marine Area Training	SILMMA Coordinator	LMMA
National	Gizo, Solomon Islands	Standardized Monitoring Protocol by the Nature Conservancy in May 2010	Approx. 20	TNC under CTSP funding
National	Gizo, Solomon Islands	Community-Based Resource Management Guidelines Workshop by WWF in October 2010	Approx. 80	CTSP/USAID
National	Honiara, Solomon Islands	Community-Based Resource Management Training of Facilitators by World Fish Center in 2010	Approx. 10	CTSP/USAID
Communities	Arnavon Islands, Solomon Islands	Look and Learn Visit for Gizo Marine Conservation Area Executives in 2011		CTSP/USAID

CTI = Coral Triangle Initiative, CTSP = Coral Triangle Support Partnership, LLMA = locally managed marine area, MPA = marine protected area, SILMMA = Solomon Islands Locally Managed Marine Area Network, TNC = The Nature Conservancy, USAID = United States Agency for International Development, WWF = World Wide Fund for Nature (formerly World Wildlife Fund).

Source: Compiled by authors.

Solomon Islands recognizes that the negative impacts of climate change could likely include a dwindling supply of food, as well as reduction in livelihood opportunities as a result of coastal habitat destruction, death of corals, and ocean acidification. These consequences of climate change will undoubtedly magnify current development issues including population growth, declining health status, rising food prices, and waste management (Australian Bureau of Meteorology and CSIRO 2011b).

The 2009 National Adaptation Programme of Action identified several sectors as being particularly vulnerable to the negative impacts of climate change:

(i) agriculture and food security;
(ii) water supply and sanitation;
(iii) education, awareness, and information;
(iv) human settlements;
(v) human health;

(vi) waste management;
(vii) fisheries and marine resources; and
(viii) infrastructure and coastal protection.

Table 10 **Initiatives for Ensuring Standardized Protocols and Guidelines for Monitoring and Data Management**

Activity	Purpose	Output	Funding Agency
TNC/SILMMA Community Monitoring Workshop, May 2010	Review and discussion of monitoring protocols used by communities in SILMMA network. Discussion of objectives and goals of community monitoring.	Manual of community-based monitoring protocol focusing on two monitoring methods: underwater visual survey and catch per unit effort (CPUE)	TNC/CTSP
Guidelines for Community-Based Marine Monitoring in Solomon Islands	Overview and review of existing biological/ecological monitoring methods currently used in Solomon Islands	Draft Guidelines for Biological and Ecological Monitoring	WWF/CTSP
Proposed Development of Management Effectiveness System for Solomon Islands	In discussion	Guidelines for Management Effectiveness Monitoring Tool	TNC/CTSP

CTSP = Coral Triangle Support Partnership, SILMMA = Solomon Islands Locally Managed Marine Area Network, TNC = The Nature Conservancy, WWF = Worldwide Fund for Nature (formerly World Wildlife Fund).
Source: Compiled by authors.

MECDM's Climate Change Division coordinates all climate change–adaptation initiatives in Solomon Islands. This includes a relatively large number of ongoing climate change–adaptation projects managed by churches, NGOs, and government agencies.

CTI activities include coordination of climate change–adaptation initiatives, particularly those relating to the marine sector. The discussion immediately below identifies ongoing CTI climate change and adaptation initiatives and provides a brief description of each.

National activities relating to adaptation to climate change

Solomon Islands is vice chair of the CTI Climate Change Adaptation (CCA) Technical Working Group.

In April 2011, the Second CCA Regional Exchange was convened in Solomon Islands with assistance from the United States (US) CTI Support Program and the Western Province Government. More than 40 participants from all six Coral Triangle countries attended. Regional exchanges arranged at the CTI level increased the degree of understanding of government staff members and NGO practitioners of the climate change challenges faced by the Coral Triangle.

MECDM's Climate Change Division is collaborating with both the CTI and other partners to implement CTI's program for addressing climate change. This collaboration focuses on seven priority actions as follows:

(i) Review the 2009 Solomon Islands National Adaptation Programme of Action particularly its provisions that relate to marine resources and coastal fisheries. Following this review, formulate a Solomon Islands national early action plan for the marine and coastal sector composed of early action measures necessary for adapting to climate change.
(ii) Continue vulnerability and adaptation assessments at priority sites. Identify the sites most vulnerable to the negative impacts of climate change. Map both the sites that are the most vulnerable and those where climate change–adaptation measures are ongoing or planned.
(iii) Continue developing guidelines for conducting assessments of vulnerability and climate change adaptation in the marine and coastal sector. This includes performing a baseline survey of coral reefs that incorporates socioeconomic indicators.
(iv) Conduct national, provincial, and community-level climate change–awareness programs. Create linkages at the national, provincial, and community levels that facilitate dissemination of news relating to climate change.
(v) Explore means currently available for improving data and information gathering and management as it relates to sea-level rise, current and future frequency and intensity of tropical storms and cyclones, changes in air and sea-surface temperatures, rainfall levels, and similar indicators of ongoing or future climate change. Similarly, explore means currently available for improving or expanding the number of initiatives that address climate change–related issues such as disaster management, meteorological science, depletion of fisheries, and resource conservation.
(vi) Formulate measures for expanding the range of livelihood options available to residents of coastal communities in the face of climate change.
(vii) Explore possible measures for integrating climate change adaptation and disaster management into MECDM initiatives.

Training

With assistance from the US CTI Support Program, two climate change–adaptation training events were convened for government staff members, NGO representatives, and field practitioners: Training of Trainers for Rhode Islands, and Training of Trainers for PNG.

These two training events enabled convening of a Solomon Islands national training session in November 2011. This latter training initiative helped more than 40 young environmental volunteers prepare a Climate Change Adaptation Local Early Action Tool Kit. Following this national-level training, these volunteers were then deployed to five provinces to raise awareness of climate change issues at the community level.

Similarly, the US Coral Triangle Initiative Support Program assisted formulation of the Joint Premiers and Mayors Communiqué that was declared in Gizo, Western Province in September 2011. The purpose of this communiqué was to secure a commitment on the part of nine Solomon Islands provincial governments to integrate climate change considerations into their respective provincial plans and programs. This commitment will be used both in future CTI initiatives, and further climate change–adaptation projects in the provinces and communities.

Once again with support from the US CTI Support Program, national climate change vulnerability and adaptation assessment guidelines were tested in the marine and coastal sector. Field activities relating to this testing were undertaken in Central Province, where community adaptation measures were identified and prioritized. This testing concluded that national CTI activities should focus on adaptation requirements at the community level using CBRM principles outlined in the Solomon Islands NPOA, and that national CTI activities should be aligned with the newly established Solomon Islands Climate Change Adaptation Policy. In addition, a community-based adaptation decision-making tool was developed under the Coral Triangle Pacific project using Isabel province as a test site. This decision-making tool will be made available to NGOs and residents of local communities in Pacific countries who are committed to (i) assessing the vulnerability of their own communities, (ii) identifying adaptation options available to them, and (iii) testing the adaptation initiatives that they themselves have chosen (e.g., rehabilitation of mangroves, diversification of livelihoods).

Goal 5: Improvement of the Status of Threatened Species

Solomon Islands has addressed issues relating to threatened marine species at the national, provincial, and local levels. National and international frameworks and strategies with the objective of protecting threatened species to which Solomon Islands is a signatory include the following:

(i) Convention of Biological Diversity;
(ii) Wildlife Protection and Management Act 1998, Regulation 2008;
(iii) Environment Act 1998, Regulation 2008;
(iv) Protected Areas Act 2010, Regulation 2012;
(v) Fisheries Act 1998;
(vi) draft species management plans for sea cucumbers, trochus, and the live reef food fish trade;
(vii) the crocodile ban;
(viii) the setting of quotas for capture and export of live dolphins;
(ix) regulation of the wildlife trade; and
(x) the Marine Turtles Strategic Action Plan.

The Red List of the International Union for the Conservation of Nature (IUCN) informs management decisions and interventions relating to the protection of threatened species in Solomon Islands. These species particularly include the leatherback turtle and the humphead wrasse. No formal red list has been formulated for Solomon Islands. Thus, in large measure, the government depends on a combination of traditional knowledge and confirmed sightings in this regard. A nationwide survey for each species would require significant technical expertise and financial support. However, due to the limited resources available to Solomon Islands, the country often depends on external support in implementing such initiatives. Thus, the only comprehensive document relating to endangered species in Solomon Islands that currently exists is a rapid assessment jointly conducted in 2004 by the Government of Solomon Islands and The Nature Conservancy. However, this rapid assessment is important in that it provides an overview of the significant degree of diversity of marine and coastal species in Solomon Islands. Detailed assessments and studies that build on the findings of this rapid assessment would greatly facilitate protection and management of threatened species in Solomon Islands.

Table 11 **Marine Protected Areas in Solomon Islands and Species Specifically Targeted for Protection**

Site/Organization	Species	Management Interventions
Arnavon Community Management Conservation Area	Marine turtles (green, leatherback, and hawksbill)	– Protection of nesting beaches – Relocation – Education and awareness/Look and learn – Research
Roviana/Vonavona Marine Protected Area Network	All species, including threatened species	– Management rules – open/closed seasons – Total ban on all species
Tetepare Island	All species, including threatened species	– Ban on harvesting – Size restrictions

Source: Compiled by the authors.

Dugongs and sharks are particularly important in this regard. Detailed assessment of dolphins in Solomon Islands waters is ongoing (Oremus et al. 2011).

Most MPAs or LMMAs address management of specific threatened species. As a result, protection of particular species is one of the objectives at a number of community-based conservation sites. Table 11 presents examples of MPAs in Solomon Islands and the species they specifically target for protection.

The SPREP *Marine Programme Strategy for 2008–2012: Whales and Dolphins, Marine Turtles and Dugong* highlights the efforts undertaken at the regional level for addressing the threats these species face. As a member of the program, Solomon Islands has aligned its national species programs with these regional activities. Solomon Islands' national species protection programs are briefly summarized below.

Marine turtles. A Marine Turtle Strategy and Action Plan for 2008–2012 has been formulated. A previous survey of green turtle–nesting beaches has been updated to show the geographic distribution of this important species. However, field surveys are necessary for confirming the results of this survey.

Dolphins and whales. Solomon Islands has gained interest from the global and regional community regarding the treatment of dolphins and whales as a result of reports of traditional dolphin hunting and dolphin exports. In partnership with the South Pacific Whales Consortium, MFMR and MECDM performed national surveys of dolphins and whales over the period 2009–2011. Focusing on genetic sampling and observations, this survey targeted four provinces: Central Islands, Guadalcanal, Isabel, and Malaita. The final report of this survey has not yet been released.

Dugong. IUCN's Red List of endangered species lists *Dugong dugon* as a vulnerable species. Information regarding this species' range and the extent of its stock in Solomon Islands is limited. While reports of local sightings of dugongs do exist, biological surveys are necessary if its geographic distribution and total population size are to be accurately determined. While Solomon Islands is not a party to the Convention on Migratory Species, in 2010 the country signed a memorandum of understanding that addresses the conservation of dugongs and their habitats.

Capacity Building

Together with MFMR, MECDM's Environment and Conservation Division (ECD) is the focal point for all CTI programs implemented in Solomon Islands. Two CTI national coordinators (one from MECDM and one from MFMR) are responsible for overall coordination of CTI initiatives. These two national coordinators are assisted by the National Coordination Committee (NCC), a multistakeholder committee composed of 15 core members drawn from relevant government departments, NGOs, and tertiary education institutions. The permanent secretaries of the two lead agencies serve as NCC co-chairs.

If implementation of the Solomon Islands NPOA is to achieve both national and regional targets, capacity-building programs will be required at all levels. In this regard, the NCC has taken the steps identified below to close existing gaps in implementation capacity relating to CTI-based initiatives.

(i) **CTI Coordination in ECD (for CTI programs).** One government officer serves as national coordinator at ECD, and another at MFMR's Inshore Fisheries Division. Both officers coordinate national-level initiatives necessary for fulfilling the objectives of the regional and national plan of action. They likewise fulfill secretariat duties for the NCC. Since 2008, both ministries have allocated appropriate amounts of staff time to ensure that the duties of these officers are fulfilled.

(ii) **Staff recruitment.** In 2009, implementation of Solomon Islands projects and programs under the US CTI Support Program was widely anticipated. A national liaison officer was thus employed for this purpose. A 3-year position housed within MECDM's ECD was created, the role of this position being to support the officers that coordinate implementation of the Solomon Islands NPOA, as well as in-country implementation of the 5-year US CTI Support Program. This same approach was used in the case of providing coordination support to the Australia CTI Support Program. This Australian-funded program provided volunteers who filled national implementation capacity gaps for 18 months. The duties of these volunteers included preparation of guidelines for monitoring and evaluation, as well as planning for implementation of specific initiatives under Australia's CTI Support Program.

(iii) **Use of existing MECDM and MFMR staff.** In the absence or limited availability of environment officers, provincial-based fisheries officers served as provincial contacts for implementation of NPOA initiatives. These officers received training in project implementation to ensure that implementation of NPOA initiatives proceeded smoothly at the provincial level. Parallel efforts are being made through other programs to establish provincial environment officer positions in each province that will assist implementation of NPOA initiatives. As MECDM is being expanded, provincial-level meteorology, climate change, and disaster management officers may likewise serve as conduits for implementing community-based resource management initiatives.

(iv) **NCC members.** Technical teams and working groups with a particular focus have been constituted within NCC as required. In addition to these technical teams and working groups, development partners that assist implementation of NPOA initiatives may also make use of provincial- or community-level contacts, support program partners, NGOs such as The Nature Conservancy, and others. This includes a capacity-building focal point and the Capacity-Building Technical Working Group.

(v) **Youth Environment Program.** In 2010, MECDM initiated a Youth Environment Program in partnership with the United Nations Development Programme (UNDP). The long-term objective of this initiative is building the implementation capacity of youths engaged in environmental initiatives. To date, 55 youth volunteers are active in this program.

(vi) **Partnerships and networks.** A broad array of projects and programs share some or all of CTI's objectives. Thus, advocates within these complementary projects and programs and those in other government agencies can help promote achievement of CTI objectives. Similarly, external advocates help further achievement of CTI objectives by creating bilateral partnerships and networks that facilitate implementation of CTI-related projects and programs. Examples of such networks include (i) SILMMA, LMMA, and MPA sites; (ii) the CTI website, which is hosted by the Solomon Islands National University, School of Natural Resources; (iii) provincial government networks; and (iv) NCC member networks.

Financial Considerations

Formulating, establishing, and maintaining community-based resource management initiatives obviously require accessing financial resources sufficient for this purpose. As a result, fund-raising and sourcing of funds have become vital components of all projects and programs that help support fulfillment of CTI objectives. These fund-raising efforts—which draw on both the public and private sectors—source funds from corporate entities, external aid agencies, multilateral banks, and government grant programs. Longer-term financing mechanisms such as user fees, PES, and trust funds have either been discussed or put on trial.

The National Biodiversity Strategy and Action Plan 2008 (Pauku and Lapo 2009) outlines sustainable financing as one of its priorities in biodiversity management. In this regard, MECDM has established a 1-year sustainable-planner-for-protected-areas position that will help formulate a sustainable financial framework with support from MamaGroun, as well as support provided by the US CTI Support Program through the Nature Conservancy,

One provision of the Protected Areas Act 2010 provides for establishing a "trust fund". However, gaps in legislation, policy, and institutional arrangements mitigate against this. To help ensure availability of financing for CTI-related initiatives, ADB's Knowledge Management Project supports exploration of the potential for introducing payment for environmental services and other sustainable financing mechanisms.

Public Awareness

Both MECDM and MFMR support environmental awareness programs, as do partner NGOs. However, at present these programs are not coordinated with one another, and are thus implemented in the absence of an overall plan. This, notwithstanding, both individual and community participants in these awareness programs are generally appreciative of the CTI and its objectives. With funding support from the US Agency for International Development, WWF and the WorldFish Center jointly conduct environmental awareness programs in Gizo Islands. Overall, these programs have been successful in making members of local communities aware

of how their resource management efforts contribute to sustaining the environmental health of the Coral Triangle overall.

Despite these successes, raising awareness on the importance of the CTI across the entire Solomon Islands could be more efficiently accomplished by adopting a coordinated approach to achieving this goal. Such an approach should take account of a number of factors. First, about 80% of the country's population lives in rural settings. As a result, the design of information materials used in awareness-raising programs must be simple and easy to understand. Preferably, these materials would contain more graphics than text.

Second, members of the urban population significantly influence the views of their *wantoks* (friends and relatives), who inhabit the country's numerous villages. Thus, the design of materials that target urban residents should be such that they relay the desired content in the clearest manner possible. This will ensure that the desired content is correctly communicated to the *wantoks* of these urban residents.

Third, some islands such as the outlying atolls of Malaita–Ontong Java are isolated and remote. As a result, they too face significant resource management challenges issues, such as unsustainable rates of exploitation of the resources available to them. However, due to a wide variety of constraints, most of which relate to logistics, limited funding, and the nature of centralized environmental awareness plans, the amount of information concerning the importance of sustainable resource management that reaches them is often limited.

Fourth, the youth comprise about 70% of the country's population. Thus, the manner in which the content relating to CTI initiatives is communicated to Solomon Islands audiences must be as appropriate to the youth as it is to other members of society. Further, the youth are in many cases the most receptive of audiences in translating new information into outward behaviors. As a result, this large segment of the national population should be engaged in a manner that encourages it to carefully consider the long-term impact of unsustainable resource management and its sustainable alternative. Finally, if approached appropriately, the probability of youthful members of society participating in CTI-related initiatives and planning over the long term is likely higher than it is for the overall population, the older members of which have long since become accustomed to long-standing behavior patterns.

The NPOA notes that education and awareness-raising efforts are vital to fulfilling the objectives of environmental action plans at both the national and regional levels. This recognition prompted the NCC to establish a communications working group. This working group is to formulate a communications plan to help the CTI and its partners achieve environmental awareness by incorporating community-based resource management principles. It is also to identify the forms of media that would be suitable for reaching populations living in remote islands, and for explicitly targeting rural, urban, and youthful audiences.

While the working group's communication plan is currently a work in progress, environmental awareness programs conducted under CTI auspices continue. These programs use a wide range of media—from national television to printed publications such as fact sheets, banners, and brochures—used in conducting community consultations and public awareness programs, such as World Environment Day. The Foundation for the Peoples of the South Pacific International, The Nature Conservancy, the WorldFish Center, and the Worldwide Fund for Nature have

played a critical role in raising awareness of the CTI and the importance of sustainable resource management in pilot communities in Western and Central Solomon Islands. This includes Central Islands, Choiseul, Guadalcanal Isabel, Malaita, and Western Province. However, widespread awareness of the CTI and the importance of sustainable resource management has yet to reach the country's eastern islands. That said, the government is hopeful that residents of all communities nationwide will eventually understand the importance of sustainable resource management, and will thus implement community-based resource management in their respective communities.

Conclusion

Sustainable management of Solomon Islands' diverse coral reef ecosystems is in one way or another vital to the livelihood of the country's entire population. Thus far, substantial progress has been achieved in achieving sustainable management of these ecosystems at the top tier of government in that necessary policies, legislation, and human resource support have been provided. Other notable achievements include recognition of the individual community of the importance of sustainable management of the country's marine resource. In this regard, government, development partners, and NGOs alike have increasingly targeted their conservation efforts toward the communities in an attempt to achieve broader understanding of the importance of sustainable resource management. That said, sustainable management of the country's marine resource will ultimately require that all owners of this resource assume responsibility for its sustainable management.

Biology and oceanography both have much to contribute to sustainable management of the country's reef ecosystems in that these disciplines can provide decision makers with baseline information vital for determining not only the current status of the country's coral reefs but also determining whether their health is improving or declining over time. Over the past 10 years, a substantial amount of progress has been made in understanding both our coral reef ecosystems and the long-term impact of alternative rates of exploitation of this resource. That said, this report finds that our understanding still has many gaps.

In particular, while relevant data have been collected to improve our understanding of the country's coral reef systems, the capacity to appropriately analyze these data in a timely manner is in many cases lacking, thus preventing meaningful use of these data. In some cases, absence of proper data storage systems is the binding constraint in providing appropriate information to policy makers. In others, though relevant, the data collected have been presented in a form that makes their processing or manipulation difficult. Finally, studies on coral reef ecosystem interrelationships, assessment of the stock of particular species, biosystematics, and coral reef ecology must be undertaken to determine the species that have been overexploited, as well as the current rate at which exploitation is occurring. Even market and household surveys would help improve our understanding in this regard.

Despite the progress that has been achieved, the country's coral reefs continue to face several threats to their sustainable management. These include (i) overfishing as a result of rapid population growth; (ii) the use of destructive fishing practices, especially that which uses surplus World War II ammunition as its primary input; (iii) logging and industrial development

activities that ignore the necessity of sustainable resource use; (iv) introduction of invasive species through a number of means; and (v) the negative impacts of climate change. Finally, particularly for countries such as Solomon Islands where a subsistence economy dominates the national economic structure, balancing the necessity of sustainable resource management with the imperative of providing livelihood to the population at large remains a challenge. Ensuring sustainable management of the Solomon Islands' coral reefs will require unwavering effort of government at all levels, as well as all economic sectors and academic disciplines. Only in this manner can the country's coral reefs be sustainably managed, and future threats to their sustainability appropriately addressed.

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State of the Coral Triangle: Solomon Islands

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