NATIONAL MARINE ECOSYSTEM SERVICE VALUATION

SOLOMON ISLANDS

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MACBIO

MARINE ECOSYSTEM SERVICE VALUATION

The living resources of the Pacific Ocean are part of the region's rich natural capital. Marine and coastal ecosystems provide benefits for all people in and beyond the region. These benefits are called ecosystem services and include a broad range of values linking the environment with development and human well-being.

Yet, the natural capital of the ocean often remains invisible. Truly recognizing the value of such resources can help to highlight their importance and prevent their unnecessary loss. The MACBIO project provides technical support to the governments of Fiji, Kiribati, Solomon Islands, Tonga and Vanuatu in identifying and highlighting the values of marine and coastal resources and their ecosystem services. Once values are more visible, governments and stakeholders can plan and manage resources more sustainably, and maintain economic and social benefits of marine and coastal biodiversity in the medium and long term.

The MACBIO Project has undertaken economic assessments of Solomon Islands' marine and coastal ecosystem services, and supports the integration of results into national policies and development planning. For a copy of all report and communication material please visit **www.macbio.pacific.info**.

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SOLOMON ISLANDS

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Marine and Coastal Biodiversity Management in Pacific Island Countries

Secretariat of the Pacific Regional Environment Programme

On behalf of: Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety of the Federal Republic of Germany

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MACBIO

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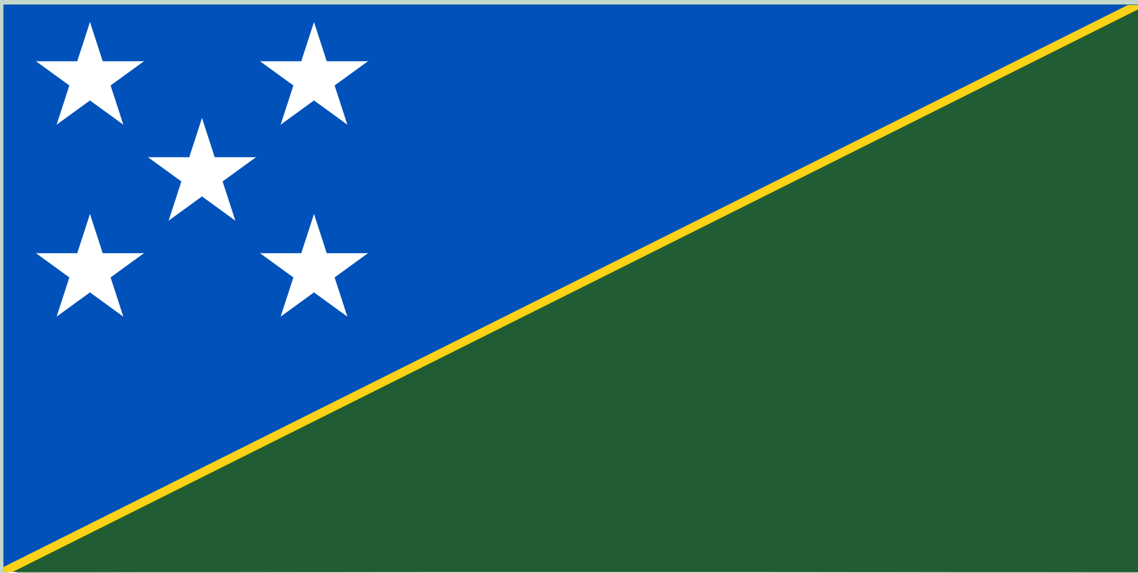


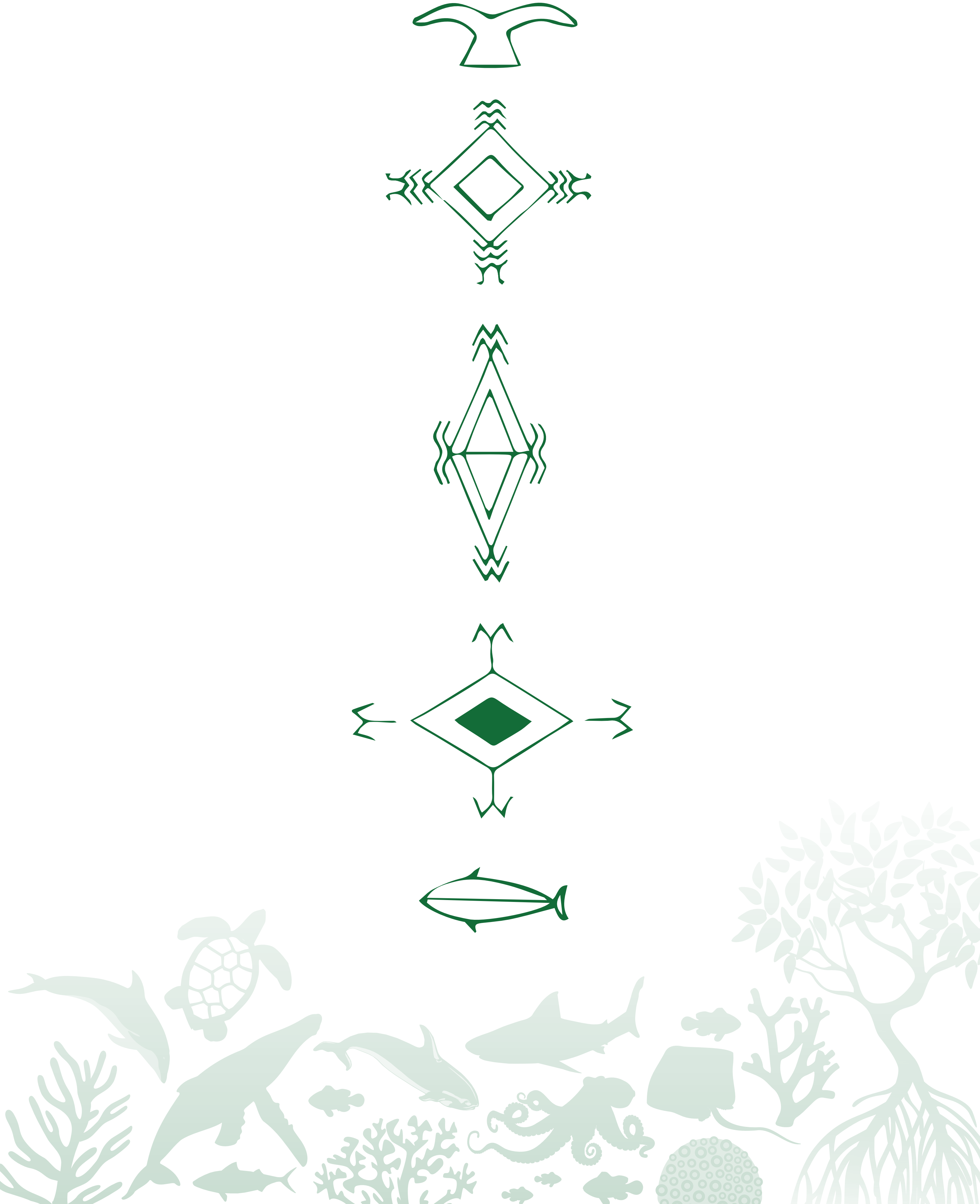
CONTENTS

CONTENTS *cont.*

FIGURES AND TABLES

ACRONYMS

ADB	Asian Development Bank
BMUB	German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
CBD	Convention on Biological Diversity
CPUE	Catch per unit effort
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DSM	Deep-sea minerals
DWFN	Distant water fishing nations
ECD	Environment Conservation Division
ECF	Ecosystem contribution factor
EEZ	Exclusive Economic Zone
ES	Ecosystem services
ESV	Ecosystem service valuation
FAD	Fish Aggregating Device
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GIZ	German Agency for International Cooperation
GNI	Gross National Income
HIES	Household Income and Expenditure Survey
IUCN	International Union for Conservation of Nature
LALSU	Land Owners Advocacy Legal Support Unit
MACBIO	Marine and Coastal Biodiversity Management in Pacific Island Countries
MCT	Ministry of Culture and Tourism
MDPAC	Ministry of Development Planning and Aid Coordination
MECDM	Ministry of Environment, Climate Change, Disaster Management and Meteorology
MESCAL	Mangrove Ecosystems for Climate Change Adaptation and Livelihoods
MESV	Marine ecosystem services valuation
MFMR	Ministry of Fisheries and Marine Resources
MMERE	Ministry of Mines, Energy and Rural Electrification
MPA	Marine Protected Area
NBSAP	National Biodiversity Strategy and Action Plan
NECDAP	National Environment and Capacity Development Action Plan
NGO	Non-government organisation
NOAA	National Oceanographic and Atmospheric Administration
OFP	Oceanic Fisheries Program
PES	Payment for ecosystem services
PICTs	Pacific Island Countries and Territories
PMO	Prime Minister's Office
PNA	Parties to the Nauru Agreement
REDD+	Reducing Emissions from Deforestation and Forest Degradation
SCC	Social cost of carbon
SILMMA	Solomon Islands Local Marine Managed Areas
SINSO	Solomon Islands Statistics National Office
SMS	Seafloor massive sulphides
SPC	Secretariat of the Pacific Community
SPREP	Secretariat of the Pacific Regional Environment Programme
TEEB	The Economics of Ecosystems and Biodiversity
TNC	The Nature Conservancy
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
USAID	United States Agency for International Development
VDS	Vessel Day Scheme
WCPFC	Western and Central Pacific Fisheries Commission
WTP	Willingness-to-pay
WWF	Worldwide Fund for Nature



EXECUTIVE SUMMARY

Solomon Islands is composed of almost 1000 islands and has the second longest coastline and the second largest Exclusive Economic Zone (EEZ) in the Pacific. These physical characteristics and the unique society and culture of the population are the basis of the fundamental relationship that Solomon Islanders have with the ocean and its *ecosystem services*[1].

This analysis aims to assist decision-makers to recognise the role that marine ecosystems play in human wellbeing. *Ecosystem services*, described as the benefits that humans receive from ecosystems, are often not fully considered in decisions, because the market fails to reveal their true value. Failure to consider the role that marine ecosystems play in supporting livelihoods, *economic activity* and human wellbeing has, in many instances, led to inequitable and unsustainable marine resource management decisions.

This study provides an economic valuation of seven marine and coastal ecosystem services in Solomon Islands: subsistence fisheries; commercial fisheries; mining for minerals and aggregates; tourism and recreation; coastal protection; carbon sequestration; and research, management and education. To provide relevant measures for policy-making, the study breaks down the analysis by provinces, highlighting how ecosystem services differ across various areas and ethnic groups. The scarcity of data about many of these ecosystem services prevents calculation of the *total economic value*; the values in this report should be regarded as minimum estimates. Data gaps are described in detail in the report.

Inshore subsistence fisheries (defined as catching fish for home/own consumption) are an important source of food for the majority of Solomon Islanders. One attribute that all of the inshore fisheries have in common is their direct and significant benefit to the people in the coastal communities of Solomon Islands. It accounts for a total SI$ 442 million/year (~US$ 58.8 million/year) which corresponds to SI$ 857/person/year (~US$ 114/person/year) and is equivalent to 5% of the *nominal* Solomon Islands Gross Domestic Product (GDP). Our estimates of subsistence fish catch are 48% higher than previous estimates. Despite potential uncertainties, this result highlights that subsistence fisheries in Solomon Islands are more important to people's livelihoods than previously thought. There are concerns regarding the sustainability of this fishery, although the intensity of fishing varies among different provinces. Guadalcanal and Malaita reefs are heavily exploited as they have the highest catches per hectare of reef, while provinces with lower population density such as Temotu and Isabel may have a more sustainable fishery as they have the lowest catches per hectare of reef. These differences in fishing effort per hectare are likely to be impacting on the stock of fish as reflected in the yields per fisher: Temotu and Isabel have the highest catch per person, while Malaita has the lowest. The study suggests that sustainable management practices should be tailored to the context of the province.

Commercial inshore fisheries include several different fisheries: coral reef and demersal fish are mainly sold in local markets; and *bêche-de-mer*, trochus and aquarium fish are traded in international markets. Although the value of these activities is low compared to the subsistence and tuna fisheries, they provide important cash income for Solomon Islanders. Coral reef and demersal fisheries account for a total of SI$ 70 million/year (~US$ 9.32 million/year), which corresponds to SI$ 156/person/year (~US$ 21/person/year) and 0.8% of the total *nominal* GDP of Solomon Islands. These values are four times higher than previously estimated. This suggests that the importance of commercial inshore fisheries may have been underestimated in the past. The sustainability of this type of fishery in Guadalcanal and Malaita is questionable, as fishing pressure in these densely populated areas is very high, similar to subsistence fishing. The fishery in less populated provinces such as Temotu and Isabel is likely to be more sustainable.

Bêche-de-mer and trochus harvesting potentially provide an important source of income for Solomon Islanders as the products are highly valued on international markets. However the value of exports of *bêche-de-mer* and trochus from 1999 to 2010 have averaged SI$ 3.34 million/year (~US$ 445,820/year) and SI$ 2.13 million/year (~US$ 284,250/year), respectively, and catches have been decreasing steadily for the past 40 years. These fisheries are overexploited and not sustainably managed. This report suggests maintaining the moratorium on the *bêche-de-mer* fishery and introducing one for trochus until biological surveys show a substantial and long-term increase in stocks.

Aquarium trade exports from 1999 to 2010 have averaged SI$ 1.22 million/year (~US$ 163,747/year). Currently, this fishery is not of concern. The report suggests introducing management practices to avoid targeting juveniles and

1 Terms in italics are explained in the glossary (Appendix I: Glossary)

vulnerable species. Control over the use of destructive fishing practices should be strengthened as they have negative impacts on this and other fisheries.

The commercial offshore fishery accounts for SI$ 1,660 million/year (~US$ 221 million/year) and targets tuna (mainly skipjack and yellowfin) almost exclusively. There are concerns regarding the sustainability aspects of this fishery because all the operating foreign vessels (99% of the total) are purse seiners and long liners and only the domestic vessels (1% of the fleet) use the more sustainable pole and line technique. One problem with this fishery is that most of the benefits accrue outside Solomon Islands as a large number of boats are foreign-owned and most of the tuna is sold on international markets. This report suggests that, for the fishery to be sustainable the existing Vessel Day Scheme (VDS) should be strongly enforced and pole and line-caught tuna should be marketed as sustainable. The current policies of the government encourage value-adding activities in Solomon Islands, which is likely to distribute more of the benefit of this ecosystem service to Solomon Islanders.

Aggregate mining on coasts or in lagoons is not common in Solomon Islands. Most aggregate mining activities are conducted in rivers. There is increasing interest in deep-sea mining. To date, Solomon Islands has only issued exploration licenses yielding *revenue* for the government of SI$ 2.74 million in 2012 (~US$ 364,000) and SI$ 998,217 (~US$ 132,962) in 2013. Given the importance of marine ecosystems for Solomon Islanders and the unknown negative impacts of deep-sea mining, the government should consider environmental risks carefully before any mining licences are issued.

Tourism expenditures from foreign visitors amount to SI$ 516 million/year (~US$ 68 million/year). According to a preliminary survey designed to estimate the contribution of marine ecosystem services to the tourism sector, 22% or SI$ 118 million/year (~US$ 15 million/year) of this value is related to marine ecosystems. Currently the sustainability of tourism is not of concern. On the contrary, tourism could be an incentive to protect marine ecosystems. The study encourages the current efforts of the government to develop sustainable tourism.

The value of coastal protection provided by coral reefs against damage from storm surges in Guadalcanal is estimated to be in the range SI$ 25–42 million/year (~US$ 3.3–5.6 million/year). The estimated value of this ecosystem service is highly uncertain and should be treated with caution. The scope of this assessment is restricted to only one aspect of coastal protection (cyclone damage), considers only damage to houses and hotels and is limited in geographic extent (Guadalcanal). The full value of this ecosystem service for Solomon Islands is likely to be considerably higher.

Carbon sequestration accounts for SI$ 161 million/year (~US$ 21 million/year) measured by the *social cost of carbon*. The potential *revenue* from the sale of carbon offsets for the protection of stored carbon in mangroves is estimated to be in the range of SI$ 55.1–72.8 million/year (US$ 7.3–9.69 million/year). Mangrove cover, however, is decreasing at an alarming rate (1.7%/year). Payment for this globally beneficial ecosystem service, through various mechanisms, for example, REDD+ or carbon offsets, might provide incentive to decrease deforestation rates.

The value of marine ecosystem research, management and education services is difficult to estimate and data were not available to conduct this valuation for Solomon Islands. Domestic government expenditure on research or management projects should be considered as a redistribution of resources, therefore not an *economic benefit*, while foreign aid can be considered a benefit to Solomon Islands' economy.

Other marine and coastal ecosystem services include mariculture, handicrafts, bioremediation, cultural identity and aesthetic beauty. These services have not been quantified in this valuation due to lack of data and human and financial resources, but they indeed provide benefits to Solomon Islands citizens and the rest of the world.

Discussions led and facilitated by the Ministry of Environment, Climate Change, Disaster Management and Meteorology and including the Ministry of Fisheries and Marine Resources have been fundamental for the development of this *ecosystem service valuation*. Throughout the development of this report, the authors endeavoured to share information about the economic value of marine ecosystems with a wide range of stakeholders with a role in marine resource use and management. These discussions indicated awareness and understanding that economic valuation information can inform development and implementation of marine resource management policies, and legislation and regulation of marine activities and, in fact, stakeholders identified several specific uses for these results.

This effort is a step towards a national process of recognising the human benefits of natural ecosystems which will lead to better management of Solomon Islands' marine resources. The information contained in this report provides current information about the *economic value* of Solomon Islands' marine and coastal assets and is a starting point for more in-depth valuations of each of the ecosystem services valued. We hope that the valuation and the considerations contained in this report contribute to more equitable and sustainable resource management decisions.

TABLE 1 • Annual economic value of marine and coastal ecosystem services in Solomon Islands (2013)

Sector	Ecosystem Service	Beneficiaries	Net Annual Value[2,3] (2013 adjusted) m = millions	Sustainability[4]
Fisheries	**Subsistence fishing**	Solomon Island households, particularly rural and low-income	SI$ 442.2m (US$ 58.9m)	Sufficient inshore habitat for sustainable subsistence harvests, but high population growth, lack of alternative protein sources, and destructive fishing practices threatens sustainability
	Inshore coral and demersal fish	Solomon Island fishers and consumers, some restaurants and businesses (only value to fishers is estimated)	SI$ 70.3m (US$ 9.4m)	As above, reef fish and invertebrates receive localized overfishing. Population pressure, and destructive fishing practices threaten sustainability
	Bêche-de-mer	Mostly export companies and foreign consumers, some local fishers, some government revenue	SI$ 3.3m (US$ 446,000) Gross export value	Over-harvesting has led to periodic closures, but inconsistent and difficult to enforce. Not sustainably managed
	Aquarium trade	Mostly foreign export companies, some government benefits and local harvesters	SI$ 1.2m (US$ 163,000) Gross export value	Unknown, but export quantities are small. Some destructive practices need monitored and controlled
	Trochus	Small-scale fishers, local and foreign consumers, exporters; some government revenue	SI$ 2.1m (US$ 284,000) Gross export value	Decades of overharvesting has depleted stocks to a condition of very low productivity in some areas
	Offshore tuna	Foreign fishing fleets, government, some local processing and fishing jobs (value is sum of government revenue and industry net economic value)	SI$ 1,659.8m (US$ 221.1m)	Skipjack stocks appear sustainable, yellowfin threatened and bigeye overfished. Membership in the Parties to the Nauru Agreement (PNA) is improving government revenue and sustainability
Mining	**Deep sea minerals**	International mining companies; government and local economic benefits depends on taxes, royalties, and business operations	SI$ 998,200 (~US$ 133,000)	Sustainability unknown; potential risks to tuna fishery, recreational fishing, and dive tourism
Tourism	**Tourism and recreation**	Solomon Island businesses (local and foreign owned) and government (marine and coastal tourism)	SI$ 118.7m (US$ 15.8m) Gross export value	Sustainable, if human pollution and damage is prevented
Regulating Services	**Coastal protection**	Citizens and visitors, in particular owners of coastal properties (measures avoided repair costs)	SI$ 25–48m (US$ 3.3–5.6m)	Sustainable, if reef is living
	Carbon sequestration	Global benefit; potential benefit to communities from carbon credits (not included in value)	SI$ 161.9m (US$ 21.6m)	Sustainable, if mangroves are protected
Foreign Investment	**Research, education, management**	Mostly government; aid money trickles through economy to organizations, consultants, and businesses (value reflects fisheries projects only)	> SI$ 9.2m (US$ 1.2m)	Depends on international relations and agreements related to nature conservation

2 Different beneficiaries (local, foreign, producer, consumer, government) are included in the value estimates; read beneficiaries column for explanation and exceptions. Gross values do not reflect costs. An exchange rate of SI$1 = US$0.1332 has been used throughout the report.

3 Unless otherwise indicated.

4 Sustainability refers to whether the values presented can be expected to decrease (unsustainable), increase, or stay the same (sustainable) with current human behaviours.

1. INTRODUCTION

1.1 MARINE AND COASTAL BIODIVERSITY MANAGEMENT IN PACIFIC ISLAND COUNTRIES (MACBIO)

Funded by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) for a period of five years through the International Climate Initiative (IKI), the Marine and Coastal Biodiversity Management in Pacific Island Countries (MACBIO) project aims to strengthen the sustainable management of marine and coastal biodiversity by supporting economic ecosystem assessments, marine spatial planning and consultations in regard to marine protected areas (MPAs). The economic valuations of marine ecosystems will contribute to national development plans. The project also aims to assist governments to extend and/or redesign MPA networks using seascape-level planning. The project will, in addition, demonstrate effective approaches for site management, including payment for ecosystem services (PES) and other conservation finance tools. Tried and tested concepts and instruments will be shared with governments and stakeholders throughout the Pacific community and disseminated internationally.

MACBIO is being implemented in five Pacific Island countries with the support of German Agency for International Cooperation (GIZ) in close collaboration with the Secretariat of the Pacific Regional Environment Programme (SPREP) and with technical support from the International Union for Conservation of Nature (IUCN).

These efforts to support improved management of marine and coastal biodiversity on the volcanic islands of Fiji, Solomon Islands and Vanuatu and the atolls of Kiribati and Tonga will help countries to meet their commitments under the Convention on Biological Diversity (CBD) Strategic Plan 2011–2020 and the relevant Aichi targets, including the Programme of Work on Protected Areas and the Programme of Work on Island Biodiversity.

All five countries are working towards achieving the quantitative Aichi Target 11: 10% of the coastal and marine environment in protected areas by 2020[5]. As of 2014, the MACBIO countries had protected the following percentages of their marine and coastal environment: Fiji = 2%; Kiribati = 11%; Solomon Islands = > 5%; Tonga = 2%; Vanuatu = > 1%. With the exception of Kiribati, the countries remain a long way from achieving this Aichi target. Most of the existing MPAs are not ecologically representative and countries lack the means to ensure the conservation and sustainable use of resources. Most countries are facing severe challenges in regard to human resources and funding, inadequate law enforcement and lack of access to the information needed for marine biodiversity management.

Under the MACBIO project, IUCN Oceania is primarily responsible for conducting national-scale economic assessments of marine and coastal ecosystem services in all five MACBIO countries, including conducting a data gap analysis. National reports on the value of marine and coastal ecosystem services will be provided to countries to inform marine spatial planning and marine resource management in general. This is one of those reports.

5 Aichi Target 11: By 2020, at least 17% of terrestrial and inland water, and 10% of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.

1.2 PROBLEM STATEMENT

Although the people and economies of the Pacific Island countries depend to a large extent on marine and coastal ecosystems, marine resource management should receive more attention in national plans and strategies (e.g. strategies relating to national development planning, tourism, food security, livelihoods, disaster mitigation and climate change adaptation) (MSWG 2005; PIFS 2007; Pratt and Govan 2011). This is due partly to a lack of understanding of the full *economic value* of marine and coastal ecosystem services (TEEB 2012).

The *economic contribution* of biodiversity and ecosystem services to the wellbeing of Pacific Islanders is understated for a variety of reasons including:

- Substantial resource-based *economic activity* exists outside of formal markets (subsistence)
- Customary resource tenure arrangements that poorly reflect individual economic decisions and pricing in markets
- Government agencies in the region typically have relatively low capacity in environmental economics and green national accounting
- Many countries of the region are relatively young and/or have lacked continuity in governance which has contributed to a lack of long-term data and analysis of ecosystem service stocks and flows at the national level
- Many countries of the region have a history of a two-tiered economy; one export and expatriate-led and the other traditional village-based and subsistence-oriented. Both tiers, however, are largely dependent on the same resource base. Planning and policy has generally struggled to address the interest of both dimensions of resource-based economic development at the national scale.

Identifying the *economic value* of marine and coastal ecosystems and taking these findings into account in national planning processes can help create incentives for more effective protection and sustainable use of marine species diversity. This, in turn, will help to sustain the benefits that people derive from those marine and coastal ecosystems.

1.3 PURPOSE AND OBJECTIVES

The MACBIO project has undertaken national-level economic assessments of marine and coastal ecosystems in the five project countries in a manner compatible with the global TEEB (The Economics of Ecosystems and Biodiversity) initiative. The work aims to contribute to national development plans and marine resource management policies and decision-making.

The principal objective of the economic component of MACBIO is to help countries to identify, quantify and, as far as possible, value in monetary units the most relevant marine and coastal ecosystem services in each MACBIO country. This should result in a national assessment of the human benefits of marine and coastal ecosystems. A comprehensive survey of the current state of knowledge and priority knowledge gaps is the first step towards accounting for marine natural capital and a *baseline* on which more detailed valuation studies could be built. The information provided within the reports can be used to guide, design and develop marine resources management plans, policies, assessments, legislation and tools, such as MPAs and environmental impact assessments.

This economic valuation is intended to enhance ecosystem-based marine and coastal resource management to lead to more resilient coastal and marine ecosystems, more effective conservation of marine biodiversity, and to contribute to climate change adaptation and mitigation, as well as to securing and strengthening local livelihoods and food security.

1.4 DESCRIPTION OF THE GEO-POLITICAL BOUNDARIES OF ANALYSIS (SCOPE)

With an area of 180 million km^2 the Pacific represents around 50% of the global sea surface and a third of the Earth's surface. The 22 Pacific Island States and Territories comprise more than 200 mountainous volcanic islands and some 2,500 flat islands and atolls. The EEZs of the five project countries cover about 7,560,000 km^2, an area the size of Australia. The project region is one of the world's centres of marine biodiversity, with an unusually large number of endemic species. Despite the outstanding importance of this biodiversity for people's food and livelihoods, comprehensive species and habitat inventories are often lacking, as well as adequate valuation of the ecosystem services they provide to people.

MACBIO, in this report, conducts a national-scale assessment of the economic value of marine ecosystem services and biodiversity. This valuation helps address one aspect of the lack of appropriate information for management decisions regarding the natural wealth of Pacific Island nations.

In the Solomon Islands, we chose to conduct a national assessment in part because it would have the largest and broadest potential relevance to policy and decision-makers. Furthermore, the human resources and funding required to conduct valuations specific to each policy or initiative related to the marine environment are unlikely to be available in small Pacific Island countries. An overview of the national value of marine and coastal ecosystem services can be used in a variety of ways, in a manner that policy-specific analyses cannot. Consider, for example:

- Although subsistence marine and coastal resource use and management primarily takes place at the village or community level, it does so within an economic and policy context at a national scale.
- Commercial fishing is often managed at the national scale (if not the regional (international) scale).
- Infrastructure investment decisions to mitigate disaster risk in coastal zones are often best managed through national planning processes in this region.
- Most Pacific Island nations have only one international airport, one main deep-water port (although the Solomons has two: Honiara and Noro) and one primary commercial centre, so any economic development policy relying on these (e.g. to do with marine tourism) becomes an issue of national policy.
- Many Pacific Island nations have committed to national planning and policy efforts under one or more UN Conventions. National-scale capacity-building, data collection, storage and analysis help to reduce redundancy and perhaps create synergies with other parallel efforts and country-scale commitments in the region.
- Many of the compensatory and regulatory policy tools available and being used to promote behaviour in line with both natural wealth management and sustainable economic development objectives are most often national-level tools. These might include PES approaches, entry and/or exit fees, hotel taxes, taboo seasons, catch limits, use of coral for construction materials, clearing of mangroves, water, sewage and solid waste disposal, among other issues and concerns.

1.5 REPORT INTRODUCTION

Solomon Islands is a Pacific Island country composed of almost 1000 islands that are home to one of the richest and most diverse marine ecosystems in the world. The country is in the eastern corner of the Coral Triangle, a region that is characterised by unique marine biodiversity. The area of its EEZ, nearly 1.58 million square kilometres, suggests how important oceans are for this country; the land area of Solomon Islands ranks 143 in the world but the EEZ is the 23rd largest in the world.

This report describes, quantifies, and where possible, calculates the *economic value* of Solomon Islands marine and coastal resources. Seven key marine ecosystem services are evaluated in detail: subsistence fishing; commercial fishing; minerals and aggregate mining; tourism; coastal protection; carbon sequestration; and research, management and education. Other services such as cultural and traditional values associated with the sea, non-market *existence values*, are described, but not analysed in detail.

All marine ecosystem services are important to Solomon Islanders. The choice to focus on these seven ecosystem services was made mainly because their valuation can be performed using widely accepted methods and existing data.

Solomon Islands' socioeconomic and institutional context, in particular the differences among different provinces, are described in Sections 2.1 and 2.2, followed by an analysis of national policies, objectives, and initiatives that could use information about the human benefits of marine ecosystems. The TEEB initiative and global framework for *ecosystem service valuation* used in this study are presented in Chapter 3. Chapter 4 provides an overview of the economic valuation literature relevant to Pacific Island States and Territories and more detail discussion of literature specifically about Solomon Islands; technical methods are explained in Chapter 5.

The core of this report is Chapter 6, the result of our assessment of marine and coastal ecosystem services. The first component of the results, **Identify**, is a clear identification of how the natural marine and coastal ecosystems provide benefits to humans, that is, how *ecosystem functions* become *ecosystem services*. The second step, **Quantify**, is a review of data that quantitatively describes the magnitude of each ecosystem service. It was determined early in the project that a lack of comprehensive and reliable data would significantly limit the depth and breadth of economic valuation of ecosystem services. In response to this obstacle, an analysis of data gaps is a core focus of the report. The step **Value** presents the *economic value* of the ecosystem service in so much as the available data allows. When possible, data are presented disaggregated by provinces to provide a clearer picture of how regions benefit differently from ecosystem services.

From year to year, Solomon Islands has seen great variability in the magnitude of benefits that come from marine and coastal ecosystems, particularly with regard to commercial fisheries. In some instances, because of swings in harvests and changes to the health of the ecosystem, an annual value of the ecosystem service is hardly relevant. This report indicates whether the natural benefits can be expected to continue, to increase, or to decrease with current practices in subsections titled **Sustainability**. Chapter 6 also describes the **Distribution** of existing ecosystem benefits.

The results for each ecosystem service are synthesised in Chapter 7.

Recommendations and suggestions for how this information could be used are presented in Chapter 8. Economic information is plagued by misinterpretation. An explanation of the caveats and shortcomings of this research as well as disclaimers for how this information should not be used are presented in Chapter 9.

2. CONTEXT

2.1 DEMOGRAPHIC AND ECONOMIC COUNTRY PROFILE

Solomon Islands is the third-largest country of the Pacific after Papua New Guinea and Fiji (Figure 1). Solomon Islands has a coastline of 9,880 km (Table 2; WRI 2012) and the provisional EEZ is 1,589,477 km^2, the second largest in the Pacific (CIA 2014). The country is composed of about 1000 islands divided into nine provinces. Each province differs in environment, population and culture. This heterogeneity results in different interactions between human systems and marine ecosystems; culture and population density are the main drivers of these differences. This report aims to identify how ecosystem services flows are distributed among the different provinces, where data allow (SINSO 2009).

TABLE 2 • Reef area and coastline length of provinces of Solomon Islands

(Spatial data source: WRI, 2012)

Province	Reef area (km^2)	Coastline length (km)
Central	96.2	1473.3
Choiseul	216.6	1807.5
Guadalcanal	103.8	804.0
Isabel	429.0	3010.8
Makira-Ulawa	83.9	869.3
Malaita	162.8	899.3
Rennell and Bellona	15.1	355.5
Temotu	223.4	1201.6
Western	421.6	3148.9

The land area of Solomon Islands is about 30,407 km^2, the second largest in the Pacific region after Papua New Guinea, More than 523,000 people live in the country with a population density that ranges from 4.5 people/km^2 in Rennell and Bellona to 42 people/km^2 in Central Province (Table 3; SINSO 2009).

TABLE 3 • Provinces and population of Solomon Islands

Province	Population	Area (km^2)	Population density (number/km^2)
Central	26,051	615	42
Choiseul	26,372	3,837	5.2
Guadalcanal	93,613	5,336	11.3
Isabel	26,158	4,136	4.9
Makira-Ulawa	40,419	3,188	12.7
Malaita	137,596	4,225	33
Rennell and Bellona	3,041	671	4.5
Temotu	21,362	895	23.9
Western	76,649	5,475	14

These statistics are remarkable considering that Solomon Islands has a relatively limited terrestrial area compared to other countries and has one of the highest ratios of coastline to land area. This characteristic, coupled with the fact that a large proportion of the inhabitants of Solomon Islands live on the coast, suggests that marine ecosystems in Solomon Islands may play a fundamental role in the economy of the country (SINSO 2009).

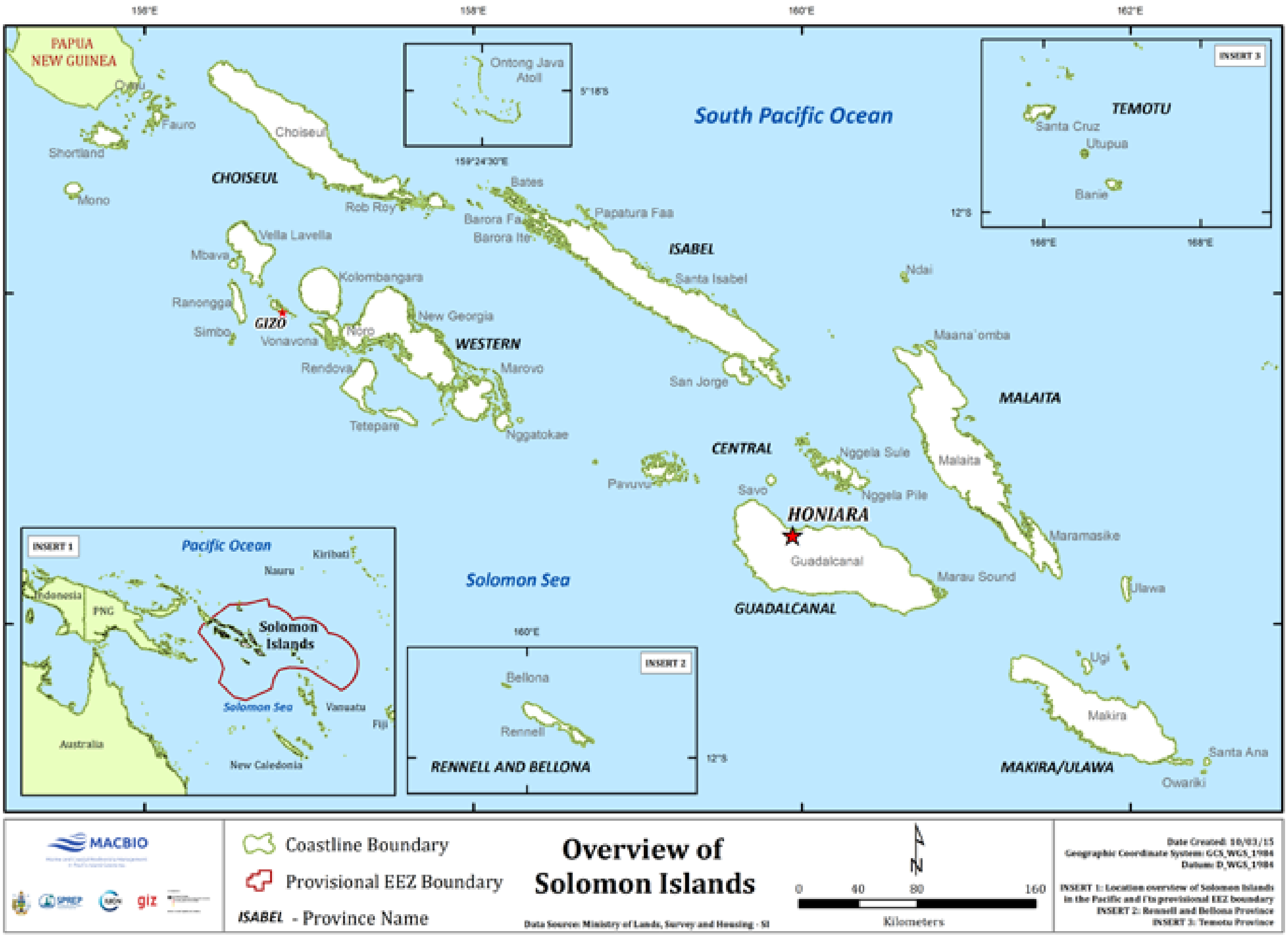


FIGURE 1 • Map of Solomon Islands

In 2014, Solomon Islands GDP was US$ 1,096.3 million/year (~SI$ 8,233.1 million/yr) (World Bank 2014). The economy grew by 3%, down from previous years of higher growth rates. GDP per capita was US$ 1,953/yr. As it is currently measured, the GDP of Solomon Islands is heavily reliant on logging and mineral extraction. Agriculture is the first sector of the economy and accounts for 51.9% of the total GDP; services make up 38.1% and industry contributes 10% (CIA 2014).

The economy is characterised by a modest commercial surplus with exports (US$ 493 million/yr) outweighing imports (US$ 446 million/yr) by US$ 47 million/yr. The main exports are timber, minerals, copra, palm oil and cocoa, going mainly to China (55.5%) and Australia (13.6%). The main imports are food, manufactured goods, fuel and chemicals from Australia (27.2%), Singapore (24.1%) and China (7%) (CIA 2014).

Subsistence fishing is undertaken by 60% of the population and contributes a large proportion of *economic activity* but is currently unrecorded. Another sector that contributes to the economy of the Solomon Islands is tourism, although it is currently relatively limited compared to other Pacific countries. However, this sector has a strong potential to grow thanks to the country's pristine marine environment (SINSO 2009).

Solomon Islands is experiencing rapid migration of people from the rural areas to the economic centres and a 2.13% population growth rate, the highest in the Pacific (World Bank 2014). Understanding how these dynamics might cause additional stresses to the marine ecosystems of Solomon Islands is fundamental for better management of stocks and flows of ecosystem services in the future (SINSO 2009).

2.2 INSTITUTIONAL CONTEXT

In Solomon Islands there are three levels of governance over the oceans: customary; provincial; and national. Approximately 80% of the land is customary land which includes foreshores, reefs and land between low- and high-water marks. This gives villagers control, ownership or rights to use of resources within the customary area. Customary rights are acknowledged by authorities and even some national and provincial laws including the *Fisheries Act 1998*, *Environment Act 1998*, *Customs Recognition Act 2000*, *Provincial Government Act 1997* and Isabel Province Natural Resource Management and Environmental Protection Ordinance 2006 (Solomon Islands Land Reform Commission 2009).

Solomon Islands is divided into nine provinces. The area of each province extends seaward for three nautical miles from the low water mark of each island, which gives the provincial authority control over these waters.

The national government's jurisdiction extends from the provincial waters to the outer extent of the EEZ. However, the government plays oversight and supporting roles to communities and provinces to effectively implement marine environment management. This support is under the mandate of the Ministry of Fisheries and Marine Resources (MFMR) and is supported by the Ministry of Environment, Climate Change, Disaster Management and Meteorology (MECDM) on specific programs such as the Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security (CTI-CFF), Convention on International Trade in Endangered Species and environmental impact assessment for coastal developments such as proposed onshore fish processing plants.

The Ministry of Environment, Climate Change, Disaster Management and Meteorology is the main contact for the MACBIO project (Table 4). The ministry's role, among others, has been to communicate with and engage key ministries such as MFMR and, most importantly, the Prime Minister's Office (PMO), on marine resource management issues, particularly on the topic of marine *ecosystem service valuation*. Although ministries play a significant role in the longevity of a program, the PMO is pivotal in influencing progress of implementation.

Different aspects of marine ecosystem services are managed by different departments within, often, different government ministries. They hold responsibility for data regarding marine resources and will be the main users of the outputs of this project, including the valuations in this report. Ministries such as the Ministry of Development Planning and Aid Coordination (MDPAC) and the Solomon Islands National Statistics Office (SINSO) are engaged, although not directly involved, in managing ecosystems. This is because these two institutions are strategically placed to discuss the inclusion of marine resource management and economic evaluations in government processes. In the case of MDPAC, the ministry is interested in identifying how marine *ecosystem service valuation* might benefit planning and decision-making processes, while SINSO was engaged to explore how future *ecosystem service valuation* data collection for the Census or other national statistics documents could benefit the government more generally.

MACBIO also involved the civil society sector that works extensively on natural resource management issues. The two main NGOs involved were WorldFish and the World Wide Fund for Nature (WWF). A complete list of the ministries and NGOs involved in the study is in Table 4 (see also Appendix II: Stakeholder consultations, attendee lists for a complete list of people involved in this study).

TABLE 4 • Ministries and NGOs involved in ecosystem valuation in Solomon Islands (MACBIO project)

Ministry	Role
Ministry of Environment, Climate Change, Disaster Management and Meteorology	Coordination Consultation and participation in MACBIO workshop
Ministry of Culture and Tourism	Consultation and participation in MACBIO workshop
Ministry of Development Planning and Aid Coordination	Consultation and participation in MACBIO workshop
Ministry of Fisheries and Marine Resources	Consultation and in MACBIO workshop
Ministry of Mines, Energy and Rural Electrification	Consultation
Solomon Islands Statistics National Office	Consultation
WorldFish	Consultation and participation in MACBIO workshop
World Wide Fund for Nature	Consultation

2.3 POLICY CONTEXT

Solomon Islands has the fastest population growth of the Pacific Island countries.

Solomon Islands joined the CBD in 1995, and has reported on the status of its implementation periodically, most recently in 2014 (Government of Solomon Islands 2014).

After signing the multilateral environment agreements UNCBD, UNFCCC (UN Framework Convention on Climate Change) and UNCCD (UN Convention to Combat Desertification), Solomon Islands carried out a national capacity self-assessment to assess its management and governance systems and to identify capacity required to implement the obligations under the conventions. This activity formed the *baseline* for development of the National Environment and Capacity Development Action Plan (NECDAP). The NECDAP drove the development of the Solomon Islands National Biodiversity Strategy and Action Plan (NBSAP) in 2009 (Government of Solomon Islands 2009).

Ecosystem service valuation is discussed in these plans and is part of Priority 4: Research, Traditional Knowledge, Science, Information System and Technology of the updated NBSAP for Solomon Islands (Government of Solomon Islands 2014). The updated target is that "*by 2020, research, encompassing traditional knowledge, science, and social science, economic investigation, has been raised including the transfer of related technologies thereby biodiversity values, functioning, status, and the consequences of their losses are better understood and managed*"(Government of Solomon Islands 2014). This shows the commitment and alignment of the Solomon Islands Government to better use of ecosystem services valuation. The government also proposes an *ecosystem service valuation* project in its NBSAP but the project is yet to be funded or implemented.

One of the challenges of international declarations that are designed to address global challenges is that, in some cases, they clash with national priorities, compete for limited resources or fail to be implemented and mainstreamed into government decisions. To overcome these challenges MECDM aims to coordinate and harness capacities from multiple in-country projects to achieve international obligations.

2.4 RELATED PROJECTS AND INITIATIVES

Ecosystem services valuation is a well-established academic discipline and very popular among development practitioners. Even though this is one of the few projects specifically on ecosystem services valuation in Solomon Islands, a considerable number of programmes and projects have collected data that are used to inform this national report.

Several projects have investigated management of fisheries and have produced useful data for assessing marine and coastal ecosystem services in Solomon Islands. For example, the Hapi Fish project and the project to develop a Solomon Islands National Inshore FAD Programme collected market and catch per unit effort (CPUE) data in different locations in the country. The New Zealand Aid-funded, Mekem Strong Solomon Islands Fisheries programme worked extensively on monitoring and surveillance of tuna stocks. Although most of the information collected is not publicly available, discussions with the project staff have provided useful insights for this publication.

The IUCN Mangrove Ecosystems for Climate Change Adaptation and Livelihoods (MESCAL) project aims to increase the resilience of Solomon Islanders through selected capacity support in adaptive co-management and restoration of mangroves and associated ecosystems. The project has gathered useful information about the status and varieties of mangroves present in the country.

In addition, the extensive work conducted by The Nature Conservancy (TNC), WorldFish and WWF focusing on sustainable management of inshore fisheries has been critical for the description of ecosystem services in Solomon Islands.

These examples are only a small sample of relevant research or natural resource management projects. A recent review has identified over 200 past and present coastal and marine projects that provide useful information to decision-makers in Solomon Islands (CSIRO, pers. comm.). We refer to them, if they were used, in the relevant sections of this report.

3. CONCEPTUAL FRAMEWORK

The primary purpose of this assessment was to provide decision-makers and policy-makers (at all levels) with information about the value that people place on their marine and coastal ecosystems. This was with a view to inform the development of decisions and policies with more concrete information about marine ecosystem values that are otherwise not fully appreciated or considered. For this reason, significant effort was made to conduct the work collaboratively, and with close interaction with key influential government and non-government stakeholders as well as technical staff within Solomon Islands.

3.1 DEFINITIONS

Ecosystems

An *ecosystem* is a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit. Natural ecosystems have varying attributes (e.g. particular species of plants and animals) and perform various functions (e.g. photosynthesis, chemical and nutrient cycling). Many of these attributes and functions benefit human activities, communities and industries.

Ecosystem services

Ecosystem services are the benefits humans receive from the natural attributes and functions of ecosystems (cf. Figure 2). These benefits could be material goods such as timber or fish, or biological services such as the treatment of human waste and carbon sequestration.

The value of marine (and other) ecosystem services to people is often not visible in markets, business transactions or in national economic accounts. Their value is often only perceived when the services are diminished or lost. Assigning monetary values to marine ecosystem services to reflect their importance to Fijians is a powerful tool to make these benefits visible and improve their wise use and management. The process of assigning monetary values to ecosystem services that benefit people is called *economic valuation*.

PROVISIONING	REGULATING	CULTURAL
• Seafoods • Building Materials • Minerals	• Coastal Protection • Carbon Sequestration	• Tourism • Recreation • Cultural Identity
	SUPPORTING	
• Nutrient Cycling	• Photosynthesis	• Habitat

FIGURE 2 • Marine ecosystem services

Economic value

Economic value refers to the quantified net benefit that humans derive from a good or service, whether or not there is a market and monetary transaction for the goods and services. Economic value needs to be distinguished from economic activity (also known as financial or exchange value), which is a measure of cash flows and is observed in markets[6]. While economic activity from market transactions is often used to calculate economic value, economic activity is not in and of itself a measure of human benefit. Economic activity, however, is an interesting measure[7]. The number of formal

6 Analysis of *economic activity* often focuses on 'multiplier effects', that is, the proportion of cash flows from one industry that spill over in to other industries due to inter-industry linkages.

7 GDP, produced through the System of National Accounts (SNA), is a measure of *economic activity*. The UN Statistics Division has recently published guidance for a System of Environmental-Economic Accounts (SEEA), which provides an accounting framework that is consistent and can be integrated with the structure, classifications, definitions and accounting rules of the SNA, thereby enabling the analysis of changes in natural capital, its contribution to the economy and the impacts of economic activities on it. It should be noted, however, that this system is restrictive in terms of the type of services and values that can be assessed.

sector jobs and the likelihood of capital investment are closely related to economic activity, and this is of interest to the public, civil servants and policy-makers. This report focuses on measuring *economic value*. Caution must be taken not to compare *economic activity* to *economic value*. Although both can be represented in dollars per year, they are different measurements of benefits.

In assessing and comparing ecosystem services, sometimes there are trade-offs to be made between different ecosystem services. For example, mining a coral reef for building materials will, likely, diminish its value as a source of food from fishing. Other ecosystem services can be complementary, for example the coastal protection value of coral reefs and their tourism value from diving or snorkelling.

Consumer and producer surplus

In general, the analysis in this report is based on the microeconomic concepts of *consumer* and *producer surplus*. *Consumer* and *producer surplus* are net measures; they measure the difference between the benefits and the costs of a particular good or service. *Producer surplus* is the benefit received by businesses, firms, or individuals who sell a good or service; *consumer surplus* is the benefit received by individuals who purchase or freely enjoy a good or service. For market transactions, *producer surplus* is synonymous with *value-added* or *profit*.

Willingness-to-pay and willingness-to-accept

Benefits are quantified by an individual's *willingness-to-pay* (WTP) or business's *willingness-to-accept*, or rather, how much money an individual or business would willingly trade for providing or receiving a good or service. The difference between consumers' maximum WTP and what they actually pay is the consumers' benefit from the transaction. Consumer WTP is represented graphically as a demand curve.

Total economic value

The *total economic value* of an ecosystem service includes all of the net benefits humans receive from that ecosystem service. *Total economic value* is a quantification of the full contribution ecosystems make to human wellbeing. *Total economic value* includes market and non-market values (i.e. *direct use value*, *indirect use value*, and *existence*, or *non-use value*) and therefore represents the full benefit humans receive from *ecosystem functions*.

In practice, *total economic value* is nearly impossible to calculate because the data required to do so are rarely available. For example, fisheries resources offer benefits to those who harvest and sell seafood products (producers), as well as those who consume seafood products (consumers). The *total economic value* of the fishery is a sum of the producer and consumer benefits. However, consumer benefits are difficult to estimate and, in the case of export products, they accrue to individuals distant from the natural resource. Producer benefits alone are commonly used to estimate the value of fisheries, as is done in this report. It should be noted, however, that these estimates are a lower-bound value and do not represent *total economic value*.

Further definitions can be found in the glossary (Appendix I: Glossary).

3.2 THE ECONOMICS OF ECOSYSTEMS AND BIODIVERSITY

As an implementing partner on the MACBIO project, IUCN Oceania is responsible for national assessment of marine and coastal ecosystem services in Fiji, Kiribati, Solomon Islands, Tonga and Vanuatu. These national reports on marine and coastal ecosystem services follow the approach for assessing ecosystem services developed by the TEEB initiative (The Economics of Ecosystems and Biodiversity; www.teebweb.org). The TEEB approach comprises six steps:

1. Specify and agree on the relevant policy issues with stakeholders
2. Identify the most relevant ecosystem services
3. Define information requirements and select appropriate methods
4. Quantify, then value, ecosystem services
5. Identify and appraise policy options and distributional impacts
6. Review, refine and report.

The MACBIO model for economic assessment of ecosystems was to conduct research in partnership with local organisations and government representatives to improve their capacity to analyse and synthesise ecosystem valuation data. In addition, this collaborative approach contributed to in-county understanding of and belief in the results of the *ecosystem service valuations*. Capacity development included basic training in resource economics concepts, recommendations for modifying or improving data collection, discussions about how economic service valuations could be used in government and elsewhere and ongoing monitoring and evaluation of ecosystem service values to achieve sustainable development. To this end, the *ecosystem service valuation* included the participation of government staff and local resource managers at every opportunity to permanently augment the capacity of country nationals to use ecosystem data and economic valuation in development of policies and resource management decision-making.

Stakeholder workshops (Figure 3) were held to identify specific applications of the economic valuation in Solomon Islands including which policy issues could be supported by more information about the values of ecosystem services (TEEB Step 1). The policy issues identified by stakeholders covered a wide range of topics (see Section 3.3). Given the resource constraints in these small countries, it was deemed unlikely that a detailed marine economic service valuation would be conducted for every policy context described. It was decided, therefore, to conduct a more generic marine *ecosystem service valuation* which could be used in whole or in part to inform a range of different existing and potential policy and decision-making situations in Solomon Islands. These workshops, and individual discussions and existing documentation, helped to identify the most relevant ecosystem services per country (Step 2).

Steps 2–6 were conducted by IUCN staff with in-country colleagues following the approach of the TEEB initiative. TEEB encourages economic valuation practitioners to engage with stakeholders not just to identify needs and policy applications for the *ecosystem service valuation* but also to develop methods for valuation that meet those particular needs and to ensure that the data provided are useful and relevant. In addition, in-country colleagues advised about the best way to communicate the results to relevant stakeholders. This report forms the basis for any communication products.

A methods guidance document (Salcone et al. 2015) was created in consultation with the country-based research teams to ensure as-consistent-as-possible treatment across the five study sites.

It is anticipated this report will provide a platform from which to identify priority actions — in terms of national policy development, national and watershed-scale data collection, regular analysis, planning and outreach — that better incorporate ecosystem service stocks, flows and values in ongoing national discussions and policy processes (Steps 5 and 6).

FIGURE 3 • Stakeholder workshop on the economic valuation of marine resources, February 2015

3.3 APPLICATIONS OF MARINE ECOSYSTEM SERVICE VALUATION

In July 2014 a workshop was conducted to introduce MACBIO to a variety of stakeholders, promote the usefulness of *ecosystem service valuation* and the TEEB process, and provide brief training on resource economics. The meeting began with an interactive game called Kasyeopoli representing pressures placed on an open-access fishery and introducing the issue of the tragedy of the commons and ecosystem services.

The workshop was helpful to gather initial information on ecosystem services valuation studies relevant to Solomon Islands, discuss previous use of ecosystem services valuation in decision-making processes and build a group of interested individuals to help gather data and participate in the quantification and valuation of ecosystem services.

During the MACBIO workshop and the many one-on-one discussions (see Appendix II: Stakeholder consultations, attendee lists for list of people involved) various uses for the results of this study were identified. Ministry staff, in particular, expressed different interests regarding how they might use this marine and coastal ecosystem services valuation.

Ministry of Environment Climate Change, Disaster Management and Meteorology

The MECDM outlined how ecosystem services valuation in general might be used to better design and implement projects and policies related to resource management. An immediate and practical use they identified was to apply the information or methods to estimate the value of compensation required for coastal land acquisitions and for permits to operate in private or customary lands (including coastal waters). This is a very delicate issue for the Government of Solomon Islands as there are many current disputes over land compensation between the government and local populations (Allen et al. 2013). These disputes result in tensions and drives investors to renounce their projects. Currently the Land Owners Advocacy Legal Support Unit (LALSU) is dealing with land disputes that in some cases also involve marine ecosystems such as land close to shore which is being considered for commercial or tourism purposes. Ecosystem services valuation could complement current methods to estimate compensation and offers an objective method to quantify at least some of the benefits derived from marine ecosystems that the land users will lose if the area is converted to other uses.

Ministry of Fisheries and Marine Resources

The MFMR is divided into four divisions overseeing offshore, inshore, and provincial fisheries, and policy and programme management. The ministry was particularly interested in two main applications of ecosystem services valuation:

1. Use the quantified benefits of inshore subsistence fisheries to show that an important portion of the provisioning services derived from marine ecosystems is not taken into account in current analyses. Information on the proportion of households (60%) engaged in subsistence fisheries suggests that these benefits contribute substantially to livelihoods and food security in Solomon Islands. Quantification has highlighted the value associated with this benefit and is a starting point to attract more attention to inshore fisheries that traditionally have been considered secondary to more profitable offshore fisheries.
2. Demonstrate the proportion of the direct and indirect benefits from offshore fisheries that accrue to Solomon Islands versus to foreign countries. This should not be limited to the direct benefits provided by the value of catches, but also other indirect benefits such as employment and taxes.

Ministry of Culture and Tourism

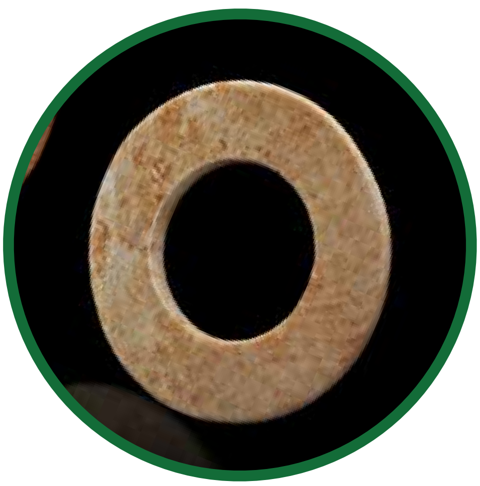
The MCT, together with the Solomon Islands Tourist Bureau, is promoting the tourism sector with various initiatives. Given the number of pristine destinations and the limited infrastructure to accommodate mass tourism that characterise other countries in the Pacific, the MCT is focusing on small-scale ecotourism which appeals to visitors interested in sustainable tourism and in activities such as scuba diving, snorkelling and other sports that are directly related to marine ecosystems.

The ministry's interest in ecosystem services valuation is to outline not just the current benefits, but the potential for marine tourism. They see that the results of the valuation might be an advocacy tool for the ministry to better identify the trade-offs between different ecosystem services in government decisions. For example, the Marovo Lagoon in

Western Province was not designated as a World Heritage site, which could have been advantageous for tourism, due to extensive logging activities in the region that have also impacted the marine environment. Ecosystem services valuation might help to better understand the potential benefits from tourism that were lost due to this impact.

During workshops, government and non-government stakeholders identified more specific types of uses to which the report results could be put:

- To inform decisions about marine resource management and how the increasing population may have an impact on marine resources
- To demonstrate the different types of value people get from marine ecosystems
- To provide an economic *baseline* from which to measure (in monetary terms) damage that may happen to ecosystems
- To increase policy-makers' understanding of the issues surrounding ecosystem management at national and provincial government levels
- To provide data that can be used to justify projects, programs and budget allocations which protect marine ecosystem services
- To make recommendations regarding investments to protect marine ecosystems
- To assess the actual value lost due to ecosystem damage to inform decisions regarding compensation for loss or damage
- To help track changes to values as different uses interact with each other and also as the desire for money increases with people living in rural areas
- To illustrate the relatively small benefits of tuna fishing to Solomon Islands
- To identify which communication products will be needed at the national level, the provincial level and the community level.



4. LITERATURE REVIEW

4.1 REGIONAL LITERATURE

This chapter summarises the literature that has been used in this report. There have been a few regional studies that investigated the value of ecosystems and ecosystem services throughout the Pacific Islands region. A general assessment of the value of Pacific Island ecosystems in 2010 estimated that coral reefs had a *total economic value* of US$ 4.11 billion or US$ 79,000 per square kilometre per year (Seidel and Lal 2010). This value was based on an extrapolation from Pacific case study estimates. *Direct use values* made up US$ 2.22 billion of this estimate, and *indirect* and *non-use values* contributed US$ 1.40 billion. *Direct use values* included fisheries, coastal protection and tourism and recreation; *indirect values* included existence and biodiversity values. Mangroves contributed a *total economic value* of US$ 4.20 billion or US$ 593,726 per square kilometre per year within the 22 Pacific Island States and Territories. This value included US$ 2.48 billion from *direct use values* (subsistence and artisanal fishing, shoreline protection, fuelwood production) and US$ 1.71 billion from *indirect* and *non-use values* (cultural and social values, *existence values*) (Seidel and Lal 2010).

A report prepared for the Asian Development Bank (ADB), the Pacific Islands Forum Fisheries Agency (FFA), and the World Bank estimated that the combined regional value of fishery and aquaculture production, including subsistence fisheries, local commercial fisheries and foreign-based commercial fisheries in nearshore and open ocean habitats was more than US$ 2.29 billion per year (Gillett 2009). Of this value, coastal commercial fisheries contributed an estimated US$ 183.1 million and coastal subsistence fisheries contributed an estimated US$ 221.4 million. These values were based on fish prices at the dock. This value was estimated to contribute as much as 10% of GDP in the region. Pacific Island States and Territories received an additional US$ 89.6 million per year in access fees and other charges to foreign fishing vessels. The same report estimated that the annual value of offshore fishing in all Pacific Island Countries and Territories (PICTs) in 2007 was more than US$ 1.7 billion, including more than US$ 681 million per year for locally-based fisheries and US$ 1.23 billion per year for foreign-based fisheries, based on dockside prices (Gillett 2009). In addition Pacific Island States and Territories received an additional US$ 89.6 million per year in access fees and other charges to foreign fishing vessels.

According to a study for the Western and Central Pacific Fisheries Commission (WCPFC) in 2012, the total estimated annual value of tuna captured in the Western and Central Pacific Ocean, based on prices paid at the processor, was US$ 7.4 billion, an increase of 23% from 2011 (Williams and Terawasi 2012). Tuna caught using purse seine nets accounted for 56% of the total value; tuna caught in the longline fishery made up 27%. Skipjack represented 49% of the total value; the rest was made up of yellowfin (30%), bigeye (15%) and albacore (6%). In 2012, fishers caught more than 2.6 million tonnes of tuna, the highest volume on record and 59% of the global tuna catch.

4.2 SOLOMON ISLANDS LITERATURE

A review of marine and coastal *ecosystem service valuation* studies, focusing on Pacific Island States and Territories, found only three valuation studies that focused exclusively on Solomon Islands (Jungwiwattanaporn et al. 2015). This review of *ecosystem service valuation* literature was focused mainly on academic journal articles and was specific to *ecosystem service valuation* studies. Kile (2000) provided a brief overview of different marine resources of the country. Lal and Kinch (2005) focused specifically on coral trade and found that the net financial *profit* earned by exporters was SI$ 1.8 million/year (~US$ 239,000/yr in 2005 prices)[8]. Albert and Schwarz (2013) showed that households living in proximity to mangroves received benefits from the ecosystem such as firewood, food and building materials that were valued at SI$ 2,590–11,269 per year per household (~US$ 345–1,501 in 2011 prices). In addition, the Secretariat of the Pacific Community (SPC) Trochus Information Bulletins and *Bêche-de-mer* Information Bulletins are invaluable resources on the status and economics of these two important fisheries of Solomon Islands.

8 The exchange rate between SI$ and US$ adopted for the report is the average of 2013: 0.1332.

Some information from regional valuation studies has been used in the valuations in this report. In addition, in some cases, the analyses relied on figures from sources that were not focused on evaluating marine ecosystem services. The analysis of inshore commercial and subsistence fisheries, for example, is based on data from PROCFish, a study that rigorously collected data on catches using four different sample sites (Pinca et al. 2009), the Solomon Islands Census (SINSO 2009) and from an unpublished market survey conducted by the Hapi Fish programme.

Finally, for the valuation of tourism and recreation, the main publication used was the Solomon Islands Tourist Survey recently published by the Ministry of Tourism (MCT 2014). Data on activities, destinations and expenditure per day were combined with information from a preliminary survey conducted by MACBIO to estimate the contribution of marine ecosystems to the benefits from tourism.

This literature review is a sample of studies related to the economics of Solomon Islands ecosystems and ecosystem services. The collection of studies related to marine and coastal ecosystems or Pacific Island economies is extensive; additional sources used to analyse each ecosystem service are referenced in the relevant sections of this report.

5. METHODS

The general methods are presented in Salcone et al. (2015). Specific details of methods applied in this report are presented below or in the relevant sections of the report.

As far as possible, government staff and other relevant parties within Solomon Islands worked with the authors to answer questions, supply information and data and to identify data gaps for this report (TEEB steps 1–4). See Appendix II: Stakeholder consultations, attendee lists for the list of people consulted. These colleagues also identified in-country policies, plans, strategies and other marine resource management tools to which this work could contribute (see Section 3.3).

5.1 OVERVIEW OF ESTIMATION METHODS

This analysis identified seven key marine and coastal ecosystem services that are described and valued in this report:

1. Subsistence food
2. Commercial food
3. Minerals and aggregate
4. Tourism and recreation
5. Coastal protection
6. Carbon sequestration
7. Environmental research, management and education

Marine and coastal ecosystems provide many more ecosystem services than the seven explored here. These seven were identified as nationally important, potentially quantifiable with existing data and amenable to policy intervention or private action.

The detailed and specific mathematical methods and data requirements for estimating the value of these seven marine and coastal ecosystem services are provided in Salcone et al. (2015). This is a methodological guidance document created in consultation with the country-based research teams and other Pacific resource economists to ensure consistent treatment across the five study sites.

Where sufficient data are available, *ecosystem service valuation* represents producer and/or *consumer surplus* and includes market and non-market values for direct and indirect ecosystem services. Where sufficient data do not exist to implement the most appropriate methods, the next best possible ecological-economic analysis has been conducted. This may include qualitative descriptors of values or references to other locations with data on the identified values. Gaps in data and previous research are partially offset with the authors' judgment based on economic theory.

Introductions to specific methods used to value each of the seven ecosystem services are given in Chapter 6. Information in the report that has no citation or source is based on the personal knowledge of the authors. Similarly, in some cases, unpublished data were sourced from government departments and have no further reference.

Unless otherwise stated, all values have been converted to 2013 United States dollars (US$) and Solomon Islands dollars (SI$). Currencies are converted using the most appropriate method to facilitate comparison of the magnitude of the benefits or costs. An exchange rate of SI$1 = US$0.1332 has been used throughout the report.

5.2 SECONDARY DATA SOURCES AND QUALITY

MACBIO was not intended to collect primary data. Instead, the objective was to locate existing sources of data that could be used for *ecosystem service valuation* and to identify data gaps. Data was obtained from government divisions, in particular MFMR, MECDM and MCT. Primary data sources from Solomon Islands Government are the 2006 Household Income and Expenditure Survey (HIES) (SINSO 2006) and the 2009 Census (SINSO 2009).

The MFMR provided information regarding costs of tuna vessels operating in Solomon Islands waters, while data regarding offshore catches were obtained from the datasets of the Oceanic Fisheries Program (OFP) of the SPC. Additional data regarding employment and exports were acquired from reports prepared for the ADB and the UN Food and Agriculture Organization (FAO) (Gillett 2009; 2011). Regarding inshore fisheries, an important contribution to estimate costs were the raw data provided by the Hapi Fish project of MFMR. The project was initiated under the Coral Triangle Support Program and supported by USAID. In 2014, the project conducted a survey in three markets of Honiara, the results of which have not been published yet. The Coral Triangle Support Program ended in 2014 and now this project is funded by the New Zealand Government through the Mekem Strong Solomon Islands Fisheries program for the next two years.

MCT provided data regarding tourism arrivals and expenditure that was combined with information elicited through a short survey conducted for the MACBIO project to estimate the value of marine ecosystems for tourism. The results of this primary data collection (50 questionnaires) are preliminary and should not be considered representative of the tourism sector. In future tourist surveys, the Solomon Islands government could add some of the questions used in the MACBIO questionnaire to facilitate ecosystem services valuation. Data regarding mangrove forests in Solomon Islands were obtained from a global dataset published by UNEP (2013) using estimates made through satellite observations.

The quality and the accuracy of the secondary data sources are discussed in more detail for each ecosystem service in the **Uncertainty** sections.

5.3 DATA GAP ANALYSIS

A major focus of this research was identifying gaps and weaknesses in data that prevented an accurate valuation of marine and coastal ecosystem services. The importance of this exercise should not be understated. This report encourages and supports the use of *ecosystem service valuation* in national planning and policy-making, but in many instances a true valuation of the human benefits of ecosystems cannot be estimated because of a shortage of ecological or socioeconomic information. These data gaps are described where ecosystem services are quantified in Chapter 6.

5.4 SYNTHESIS AND EXTRAPOLATION

The valuation of ecosystem services requires a substantial amount of data that are not always available in national statistics, but may be available from case studies. For this reason one of the main methods adopted by this report has been extrapolating data from case studies to the national level using Census and HIES information.

This method is robust because it is based on official statistics characterised by robust sampling techniques. However, for some attributes it was necessary to assume that data from case studies corresponded to the national average. The plausibility of these assumptions are discussed and tested, but a certain degree of uncertainty still remains.

As shown in Chapter 6, the report presents the results of the analysis disaggregated by province. There are two main reasons for this. The first regards the heterogeneity that characterises the different areas of Solomon Islands. Provinces differ not only in their ecosystems, but also in culture and resource management practices. For this reason a national average would not have been representative in some cases. The second reason regards the use of ecosystem services valuation. National average values can be very useful for advocacy to highlight the importance of ecosystem services in the overall economy; however, they are not always as useful to inform decision-making and guide resource management policies and interventions on the ground.

6. RESULTS

This section includes the identification, quantification, and where possible, valuation of Solomon Islands' most significant marine and coastal ecosystem services. The first subsection for each ecosystem service, **Identify**, describes the ecosystem service and the relation between the ecological or biological processes of that ecosystem (the *ecosystem functions*) and the human benefits (the *ecosystem services*). This subsection also describes the human activities and livelihoods that are related to the ecosystem service. The second subsection, **Quantify**, describes data that illustrate the magnitude of the service either in monetary units or ecological measures and evaluates data gaps. Where sufficient data could be collected, the third subsection, **Value**, presents the *economic value* of the ecosystem service. The value represents a quantification of human benefits in terms of local monetary currency.

The **Sustainability** and **Distribution** of ecosystem service benefits is evaluated following the valuation of each service. It is important to understand whether human benefits can be maintained or if they are expected to decrease because of unsustainable resource use or management practices. It is also important to recognise who receives the benefits from the ecosystem, whether it be poor or wealthy households, government, visitors or foreign nations. The **Uncertainty** of each value estimate is also discussed in this section.

6.1 SUBSISTENCE FISHERIES

6.1.1 IDENTIFY

Subsistence fishing refers to harvesting of seafood species that are consumed, given, or exchanged by fishers without any monetary transaction. In Pacific Island countries, particularly in rural coastal areas, subsistence fishing contributes significantly to household diets and therefore has substantial *economic value* (Gillett 2009).

By providing appropriate food and habitat conditions, mangroves, seagrass, coral reefs and open sea ecosystems support the growth and reproduction of a range of fish and invertebrate species that become food for humans, including groupers, surgeonfish, parrotfish, clams, crabs, octopus, sea cucumbers (*bêche-de-mer*) and shellfish.

A Rapid Ecological Assessment conducted by TNC in 2004 found that the marine biodiversity of Solomon Islands was extremely high (Green et al. 2006). The survey indicated that 80% of seagrass species of the Indo-Pacific region were found in Solomon Islands, as well as extraordinarily high coral diversity (790 species of corals) and rich concentrations of

Subsistence fishing is undertaken by 60 percent of the population and contributes a large proportion of economic activity.

reef fishes: 1019 species, representing 82 families and 348 genera. Of these 82 families, only 20 are considered food fish families and five are fundamental for Solomon Islander families: (in order of importance) snappers (Lutjanidae), surgeon fish (Acanthuridae), parrotfish (Scaridae), groupers (Serranidae) and emperor fish (Lethrinidae) (Pinca et al. 2009).

Each of these species requires a particular habitat in order to thrive and reproduce. The reproduction and growth of fish, and thus the potential magnitude of this ecosystem service, depends on the functions provided by marine habitats, including tidal seagrass beds, coastal mangroves, coral reefs, soft seabed communities and deep-water seamounts. The functions of each ecosystem depend on natural geographical and biological factors, such as coastal bathymetry and sea currents, as well as human factors such as pollution, habitat destruction, and over-harvesting. Unlike agricultural systems, which require constant and often intensive human labour, these marine ecosystems produce food naturally, as long as they are not damaged or overexploited.

In Solomon Islands, the main source of food from subsistence fisheries is coral reef finfish. Fishing is largely from un-motorised canoes or hand line fishing. The main fishing techniques are hook and line, hand collection, various types of traditional netting, and spearing by both wading and diving (Gillett and Lightfoot 2001).

Subsistence fisheries in Solomon Islands are characterised by specialised knowledge handed down through generations. It is often labour-intensive work that in some cases involves the entire community. There is sharing of the catch among the community, social restrictions/prohibitions, and segregation of activities by gender. The traditional fishing practices of the country are extremely diverse and vary considerably between island and ethnic groups (Gillett and Lightfoot 2001).

The *Fishery Management Act 2015* objective is to ensure the long-term management, conservation, development and sustainable use of Solomon Islands fisheries and marine ecosystems for the benefit of the people of Solomon Islands. This includes provisions to do with supporting, in law, Community Fisheries Management Plans.

6.1.2 QUANTIFY

The only data on annual catches for subsistence fisheries are outdated and did not specify sources or methods (World Bank 2000). Gillett (2009) adjusted these data to 2006 using population growth as an inflator and assuming that food consumption per person remained constant. His estimation amounts to a total catch of subsistence fishing for the country of 15 000 tonnes/yr in 2006. Adjusted to 2013[9], this number corresponds to 17 550 tonnes. Given the uncertainty regarding the original methods, we conducted an additional assessment based on more recent data (Table 5).

TABLE 5 • Main sources of data used to estimate annual subsistence fishing catch

Statistic	Data	Source/author	Method
Catch per year	Finfish: 90.35 kg/person/yr Invertebrates: 16.43 kg/person/yr Total: 106.78 kg/person/yr	PROCFish, SPC (Pinca et al. 2009)	Survey in four villages (Average values)
Number of households catching fish by frequency and by province[10]	More than once a week: 25,450 (20%) Once a week: 1,137 (31%) Once a month: 7,389 (9%) Never: 32,018 (39%)	Census (SINSO 2009)	Census
Percent of catch for own consumption (vs. sold)	59%	PROCFish, SPC (Pinca et al. 2009)	Survey in four villages

Given the average catch per year (106.78 kg/person/yr) and information on frequency of fishing trips per week provided by PROCFish (Pinca et al. 2009), we estimated that, on average, a household that fishes only once a week catches in total 363 kg/yr, households that fish more than once a week catch 1270 kg/yr, and households that fish only once a month catch 90 kg/yr. These figures, combined with the number of households catching fish by frequency and by province (SINSO 2009) and the percentages of catch for own consumption 59% (Pinca et al. 2009) results in total average subsistence catch for the country of 33,561 tonnes (Table 6).

9 The inflator used is population growth from 2006 to 2013, amounting to 17% (World Bank 2014)

10 In this table only figures per household are included. The analysis was conducted using information by province.

TABLE 6 • Subsistence fisheries catch (tonnes) by province, 2013

Province	Total population	Total catch (t)	Catch per kilometre of coast (kg/km)	Catch per ha of reef (kg/ha)
Central	26,051	2,214	1,503	230
Choiseul	26,372	2,482	1,373	115
Guadalcanal	93,613	5,625	6,996	542
Isabel	26,158	1,964	653	46
Makira-Ulawa	40,419	3,162	3,638	377
Malaita	137,596	8,131	9,043	499
Rennell and Bellona	3,041	205	579	136
Temotu	2,1362	1,956	1,629	88
Western	76,649	7,263	2,307	172
Honiara	64,609	554		
Total	**516,147**	**33,556**	**2,473**	**192**

This result is 48% higher than the previous estimates (World Bank 2000; Gillett 2009) highlighting that subsistence fisheries may play a more important role in the livelihoods of Solomon Islanders than previously thought. These values are based on the most recent data available. Even though these values are subject to a certain degree of uncertainty (see Section 6.1.4) they may be more accurate than those of Gillett (2009) which were based on a World Bank study from 2000 that did not state its estimation methods. Regardless, it is likely that the *real* catch of subsistence fishers in Solomon Islands lies between 17,500 tonnes/yr and 33,556 tonnes/yr, most likely closer to the upper end of this range.

6.1.3 VALUE

The value of this ecosystem service can be quantified by measuring the *consumer* and *producer surplus*. Given that, in subsistence fisheries, the consumer is also the producer we only quantify the latter, adopting the methodology proposed Salcone et al. (2015). Usually the literature presents information on ecosystem services as the total value of catches, however, to quantify *producer surplus* it is necessary to subtract costs from the total value of catch. This then represents the net benefit that fishers receive from marine ecosystems.

$$\text{Subsistence Surplus} = \left(\text{Subsistence Harvest}_{kg} \cdot \text{Price Protein Equiv.}_{\frac{\$}{kg}}\right) - \text{Harvest Costs}_{\$}$$

The subsistence harvest is 33,561 tonnes. The average price of fish was SI$ 19.17/kg estimated from three markets in Honiara[11]. This price represents the price of protein equivalent, which is assumed to be the best and cheapest alternative option to subsistence fisheries.

The harvest costs were calculated using the information from the Hapi Fish database (making sure that transportation, market fees and other costs associated with selling fish were not taken into account) to reveal the *total economic value* of subsistence fisheries. Table 7 summarises the *value-added* per year, and also the *value-added* (benefit) per person and per kilometre of coast. Figure 4 illustrates the breakdown of *value-added* by province.

11 This figure is estimated using figures from the Hapi Fish database based on surveys collected in the three main fish markets of Honiara between 2013 and 2014.

TABLE 7 • Value-added of subsistence fisheries by province

Province	Total population	Total value-added per year (SI$)	Value-added per person per year (SI$)	Value-added per km of coast (SI$/km)	Value-added per ha of reef (SI$/ha)
Central	26,051	29,179,088	1,120	19,805	3,033
Choiseul	26,372	32,701,921	1,240	18,093	1,510
Guadalcanal	93,613	74,110,139	792	92,176	7,141
Isabel	26,158	25,885,468	990	8,598	603
Makira-Ulawa	40,419	41,668,128	1,031	47,936	4,963
Malaita	137,596	107,134,394	779	119,136	6,579
Rennell and Bellona	3,041	2,711,692	892	7,629	1,794
Temotu	21,362	25,782,042	1,192	21,456	1,154
Western	76,649	95,688,218	1,248	30,388	2,270
Honiara	64,609	7,405,272	113		
Total	516,147	442,166,362	857	32,584	2,523

Note: value includes all fish and invertebrates caught within and outside the reef.

Thus, the *total economic value* of the subsistence fishery for Solomon Islands is estimated to be SI$ 442,166,362/year (~US$ 58.8 million/year) (Table 7). Considering that Solomon Islands GDP is US$ 1,096.3 million/year, the value of subsistence fisheries is equivalent to 5% of the *nominal* GDP.

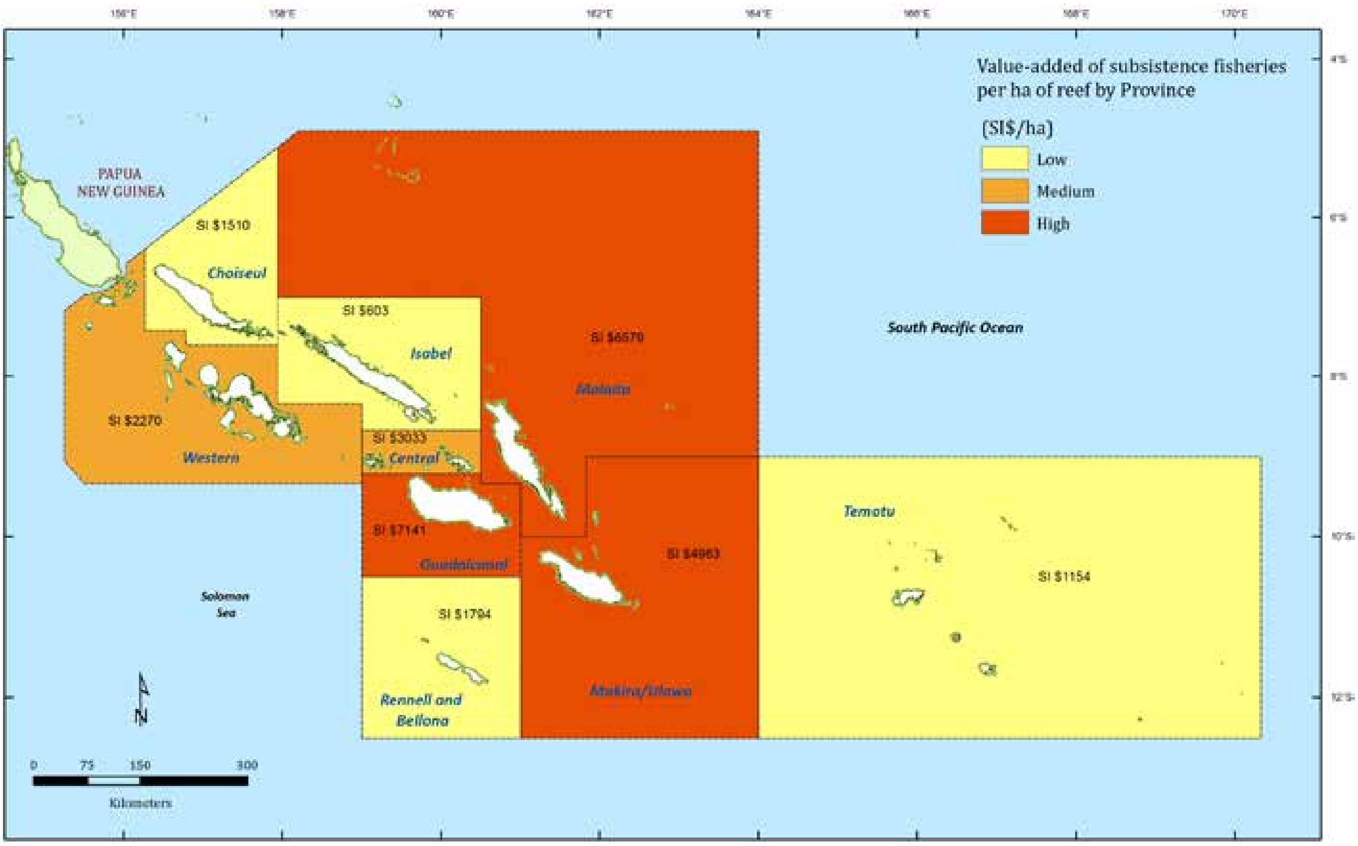


FIGURE 4 • Value-added of subsistence fisheries per hectare of reef by province

6.1.4 UNCERTAINTY

The Solomon Islands Census does not collect information on household catches from subsistence fisheries; therefore this figure was estimated using indirect methods. Uncertainty arose at multiple steps in the analysis. The first source of uncertainty was the measurement of the average catches per households. This estimate was based on surveys from four different villages that were chosen as close to the national average (Pinca et al. 2009). However, this sample might result in an overestimate of the national average catch, particularly because one of the criteria for the sample selection was that the villages had active reef fisheries.

The second source of uncertainty regards the calculation of how often households go fishing. The Census categorised frequency of fishing qualitatively rather than quantitatively. Therefore, the frequency assessment cannot yield precise annual estimates.

The third source of uncertainty regards the fishing costs and price of fish. These were estimated using information from a database that has not yet been reviewed and contains information from only three markets in Honiara. Although these markets are attended by fishers from different provinces, the sample may not be representative of the national average for costs. The price of fish is likely to be overestimated compared to the national average because prices are generally higher in Honiara, the capital and the main economic centre of the nation, than in the other regions.

In future, subsistence fisheries could be estimated with a much higher level of accuracy if the next Census includes quantitative questions regarding catches and fishing frequency. The Hapi Fish database is also expected to start including markets in other provinces. This will allow the government and future researchers to estimate the harvest costs and market prices with much higher accuracy.

6.1.5 SUSTAINABILITY

The biological and social survey conducted by PROCFish in 2006 indicated that, at the four selected sites, there was high pressure on marine resources (finfish, invertebrates and shellfish). The drivers of this pressure were population density, high fish consumption in coastal villages and the continuing use of destructive fishing practices such as dynamite and fish poisoning. This pressure is likely to increase given that Solomon Islands has the fastest population growth of the Pacific Island countries (Pinca et al. 2009).

Some species are more exploited than others and those that are also fished for commercial purposes are the most vulnerable (e.g. trochus, *bêche-de-mer*, giant clams). Commercialisation and export markets, in particular, can jeopardise the sustainability of the subsistence fishery and threaten food security.

The disaggregation of the results by province provides some information about the relative level of exploitation of fisheries within Solomon Islands. In particular, Table 7, Columns 5 and 6 provide a rough indication of the intensity of fishing activity per province by comparing the catches and benefits to the length of the coast and the area of reef. According to some of these measures the provinces that have the highest volume of catch per hectare were Guadalcanal (SI$ 7,141/ha/yr) (~US$ 951/ha/year), Malaita (SI$ 6,579/ha/yr) and Makira-Ulawa (SI$ 4,963/ha/yr), while the lowest were Choiseul (SI$ 1,510/ha/yr), Temotu (SI$ 1,154/ha/yr) and Isabel (SI$ 603/ha/yr) (~US$ 80/ha/yr). It is not surprising that the provinces characterised by higher fishing intensity are also those that have higher population density (Table 3) This corroborates the previous argument of population density as a driver of high pressure on marine resources.

A high volume of catch per kilometre might correspond to lower catches per person as people fish less frequently due to depleted resources. Both Guadalcanal and Malaita show this trend. Both these provinces have a very high *value-added* per hectare, but the lowest *value-added* per person (SI$ 772/yr and SI$ 779/yr; ~US$ 102–103/yr).

6.1.6 DISTRIBUTION

Nationally, the *value-added* of catches per person per year amounts to SI$ 857 (~US$ 114). This number may not reflect the importance of subsistence fisheries for the diet of Solomon Islanders. This value is an average that also takes into account the 39% of households that do not practice subsistence fishing.

Disaggregating the *value-added* of catches per household by different fishing effort per month sheds more light on how the importance of subsistence fisheries differs depending on the characteristic of the household. As shown in Table 8, 20% of the population fish more than once a week and the *value-added* of catches per person per year is SI$ 3,044. This amounts to SI$ 8 (~US$ 1.20) per day. On the other hand, 39% of the population does not practice subsistence fisheries at all.

TABLE 8 • Value-added of subsistence catch per person disaggregated by type of household

	Type of household			
	Fish more than once a week	Fish once a week	Fish once a month	Does not fish
Number	90,307	139,976	40,638	176,099
Percentage of population	20%	31%	9%	39%
Value (SI$)	3,044	869	217	0

It is reasonable to assume that coastal communities are more likely to fish than inland communities. On this basis, one can say that the benefits of this ecosystem service accrue mainly to coastal communities of Solomon Islands.

6.2 COMMERCIAL FISHERIES

Commercial fishing refers to fishing or harvesting of seafood that is then sold or exchanged via a monetary transaction. Commercial fishing is a large component of many Pacific Island economies. The EEZs of Pacific Island countries are home to large stocks of seafood that are food for people throughout the world. The Western Pacific skipjack tuna fishery is the world's largest natural source of animal protein. Millions of square miles of reef and lagoon habitat support the reproduction of a wide variety of commercially popular seafood, such as lobster, coral trout and sea cucumber (*bêche-de-mer*).

The commercial fishing ecosystem service is described by fishery sector: inshore or offshore. Inshore fisheries occur on reefs, lagoons, among mangroves, intertidal zones or other areas that have relatively shallow water and are home to non-migratory fish and invertebrate species. Offshore fisheries occur in deep-water areas that are home to sharks, billfish, tuna, and deep-water snapper and jobfish. Two sectors are evaluated: inshore reef fish and invertebrates; and offshore tuna. The *bêche-de-mer*, shark, aquarium and coral trades are also discussed using figures reported by other studies that focused in more detail on these products.

Because countries can exclude others from fishing within their waters, a *resource rent* can be earned from seafood products. A *resource rent* is a margin of *profit* that can be earned because access to the resource is limited. This is the nature of an EEZ — foreign fishers and companies can be excluded and/or regulated. When a country charges a license fee for access to its EEZ, they are taking some of the *resource rent* earned by the fishers. This *resource rent* is a benefit to Pacific Island countries, including Solomon Islands.

Commercial fisheries can also be classified depending on whether they are directed to internal or external markets. Several sources of information regarding fisheries exports are available, but less is known about the amount of fish sold at internal markets.

The FAO (2012) reported that the total value of fisheries exports from Solomon Islands was SI$ 240 million (~US$ 32 million). According to the Harvard atlas of economic complexity, 'frozen fish' and 'prepared or preserved fish' accounted for 6.03% and 3.32% of the total exports of Solomon Islands respectively after the two main export products, wood and gold (Centre for International Development, 2014).

The value of annual fisheries exports (at *constant prices* deflated using the FAO fisheries price index) does not show a particular trend and varies substantially from year to year (Figure 5). This could be due to international market shifts, crashes in fish stocks, periodic changes in licensing and other fishing regulations, and also to recent political and ethnic tensions in Solomon Islands.

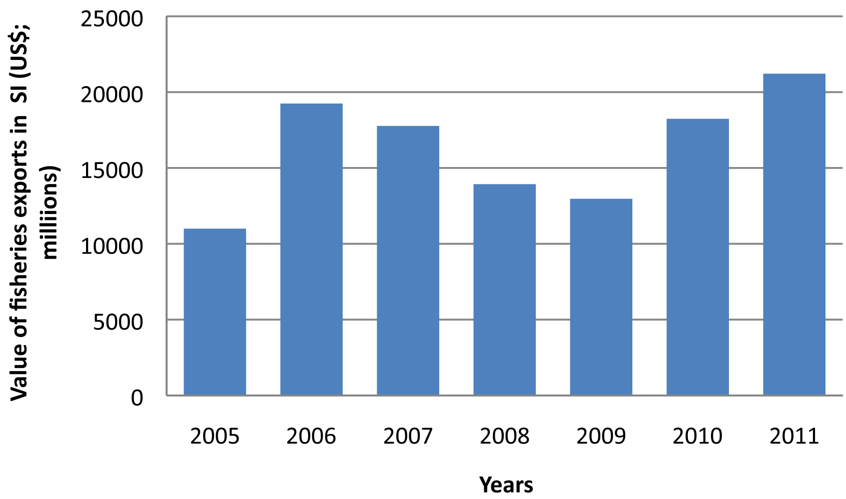


FIGURE 5 • Value of fisheries exports, 2005–2011 (US$) Source: FAO (2012)

Note that these values do not represent the total gross value of commercial fisheries that operate within the Solomon Islands EEZ because a large amount of the catches of high-value seafood, such as tuna, are not landed in Solomon Islands and therefore are not taken into account in official statistics. In addition, the value of fisheries exports does not include seafood sold on national markets.

The 2009 HIES reported that the number of workers in fisheries and aquaculture was 5,756: 12% female and 88% male. This figure has not changed significantly since 2001 and 2004, when there were 5,179 and 5,114 formal jobs in the fishery sector respectively (IMF 2005). These data only report on formal jobs and almost certainly underestimate the true number of people involved in the commercial fishery sector that are not considered formally employed. For example, Berdach and Llegu (2005) estimated that 30,000 Solomon Islanders worked in semi-commercial or artisanal fisheries.

6.2.1 INSHORE FISHERIES

The inshore commercial fishery in Solomon Islands can be divided into different categories: finfish and invertebrates, *bêche-de-mer* (sea cucumber), aquarium trade (coral and shell) and trochus. We also consider the dolphin fishery as an inshore fishery in this study because it is mainly conducted very close to the coast with the dolphin drive hunting method (Oremus et al. 2015). Given the lack of information only finfish and invertebrates were analysed and valued in detail. A rapid valuation was conducted for *bêche-de-mer*, ornamental fish, coral trade and trochus, while the rest of the inshore marine resources fished commercially are discussed separately, in a section referring to information from other studies.

Inshore fisheries have a direct and significant benefit to the people in the coastal communities of Solomon Islands.

6.2.1.1 REEF FISHERIES AND INVERTEBRATES

Identify

The marine products sold in the main markets of Solomon Islands are mainly reef fish and invertebrates of different kinds sold by middlemen and usually caught by local fishers. In the main markets such as Honiara there are also middlemen that sell fish bought from other provinces. Most of these catches are consumed locally except for shark fins, rock lobsters, ornamental fish and some dolphins which are exported and sold in international markets (Table 9). In particular, dolphins are caught to be sold alive to sea aquariums mainly in China and Dubai, or in other cases sold on local markets for their meat and teeth. In Solomon Islands, dolphin teeth are used to produce necklaces and bracelets and can cost around SI$ 5 each (US$ 0.66) (Oremus et al. 2015).

TABLE 9 • Reef fishery exports, 2005 and 2006 (US$)

Product	2005 (US$/yr)	2006 (US$/yr)
Shark fin	70,000	90,000
Rock lobster	69,000	113,000
Ornamental fish	229,000	226,000

Source: FAO 2008; Gillett 2009

The main fishing techniques are hook and line, hand collection, various types of traditional netting, and spearing by both wading and diving (Gillett 2008). Reef fish and invertebrates are caught largely from un-motorised canoes. The main fishing technique for dolphins is drive hunting with motor boats, while ornamental reef fish and invertebrates are caught largely from un-motorised canoes or in a few cases with more modern boats.

Quantify

There are no existing estimates of the catch of commercial reef fisheries and invertebrates. The same method used to estimate catches from subsistence fisheries is adopted to quantify this ecosystem service. The main difference is that this report uses data on catches sold instead of using catches for own consumption and takes into account selling costs. Table 10 summarises the data used for this analysis. Note that this analysis excludes *bêche-de-mer*, the aquarium and coral trade and trochus.

TABLE 10 • Main sources of data to estimate annual commercial catch of reef fish and invertebrates

Statistic	Data	Author/source	Method
Catch per year	Finfish: 90.35 kg/person/yr Invertebrates: 16.43 kg/person/yr Total: 106.78 kg/person/yr	ProcFish, SPC (Pinca et al. 2009)	Survey in four villages (average values)
Number of households catching fish by frequency and by province	More than once a week: 25,450 (20%) Once a week: 1,137 (31%) Once a month: 7,389 (9%) Never: 32,018 (39%)	Census (SINSO 2009)	Census
Percent of catch sold	41%	ProcFish, SPC (Pinca et al. 2009)	Survey in four villages (average values)

In this table only figures per household are included. The analysis is conducted using information by province.

Given the average total catch per year (106.78 kg/yr) and information on frequency of fishing trips per week (Pinca et al. 2009) we estimated that on average a household that fishes only once a week catches in total 363.18 kg/yr (total catch for Solomon Islands is 55,957 t/yr). We estimate that 43% (22,369 t) of this total catch is for sale, while 57% (33,561 t) is for own consumption (Table 10).

TABLE 11 • Commercial reef finfish and invertebrate catch by province

Province	Population	Total catch (t)	Catch per kilometre of coast (kg/km)	Catch per ha of reef (kg/ha)
Central	26,051	1,611	1,094	167
Choiseul	26,372	1,805	999	83
Guadalcanal	93,613	4,092	5,090	394
Isabel	26,158	1,429	475	33
Makira-Ulawa	40,419	2,300	2,647	274
Malaita	137,596	5,915	6,579	363
Rennell and Bellona	3,041	149	421	99
Temotu	21,362	1,423	1,185	64
Western	76,649	5,283	1,678	125
Honiara	64,609	403		
Total	516,147	24,410	1,799	139

The total catches for commercial reef finfish and invertebrate fisheries amounts to 24,410 t/yr, less than 66% of the volume of subsistence fisheries. Western Province and Malaita have the highest catch, while Temotu, Honiara and Rennell and Bellona the lowest (Table 11).

Value

The *total economic value* of this ecosystem service can be quantified by measuring the consumer and the *producer surplus* obtained from the capture, sale, and purchase of fish products. The valuation of the *consumer surplus* requires estimation of a price demand curve, which is beyond the scope of this project (see Salcone et al. 2015 for more). For this reason, we only estimate the *producer surplus* adopting the methodology proposed by Salcone et al. (2015). Usually the literature presents information on the ecosystem services as the total value of catches. However, to quantify the *producer surplus*, is necessary to subtract costs from the total value of catch, in order to capture the net benefits that fishers receive from marine ecosystems.

$$\text{Producer surplus} = \text{Commercial Fishing Revenue}_{\$} - \text{Commercial Fishing Costs}_{\$}$$

$$\text{Commercial Fishing Revenue}_{(\$)} = \left(\sum \text{Fishingtime}_{i(hrs)} \cdot \text{CPUE}_i\left(\frac{kg}{hr}\right) \cdot \text{Price}_i\left(\frac{\$}{kg}\right) \right)$$

The commercial inshore fishery harvest (22,396 t) is multiplied by the average price of fish (SI$ 19.17/kg) of three markets in Honiara (from the Hapi Fish database).

The harvest costs were measured using the information from the Hapi Fish database, which gathers data from the three main fish markets of Honiara. Harvest costs differ greatly depending on the origin of the fish because transportation costs from other provinces are high, potentially including fuel, ferry fees, ice, and/or land transportation costs. For this reason, the harvest costs of catches from other provinces have been measured including transportation costs; transport costs were not included for catches from Honiara and Guadalcanal. This is reflected in the higher *value-added* ratio of Honiara and Guadalcanal (Table 12).

However, not all the catches from other provinces are sold in the markets in Honiara. In the absence of data on the distribution of catch sold within Solomon Islands, it was arbitrarily assumed that 50% of the catches in other provinces are sold in Honiara, while the rest is sold locally.

TABLE 12 • Value-added of commercial inshore reef finfish and invertebrate fisheries per province, 2013

Province	Population	Value-added ratio	Value-added (SI$ '000)	Value-added per person (SI$)	Value-added per km of coast (SI$/km/yr)	Value-added per ha of reef (SI$/km²/yr)
Central	26,051	1.11	3,307	127	2,245	344
Choiseul	26,372	1.11	3,707	141	2,051	171
Guadalcanal	93,613	1.37	29,430	314	36,605	2,836
Isabel	26,158	1.11	2,934	112	975	68
Makira-Ulawa	40,419	1.11	4,723	117	5,434	563
Malaita	137,596	1.11	12,144	88	13,505	746
Rennell and Bellona	3,041	1.11	307	101	865	203
Temotu	21,362	1.11	2,922	135	2,432	131
Western	76,649	1.11	10,847	142	3,445	257
Honiara	64,609	1.37	2,901	45		
Total	516,147	1.10	70,326	156	5,182	401

Note: value includes all fish and invertebrates caught within and outside the reef.

The *total economic value* of artisanal commercial fishing in Solomon Islands is estimated to be SI$ 70 million/yr (~US$ 9.3 million/yr) (Table 12). Considering that Solomon Islands GDP is US$ 1,096.3 million/yr, commercial inshore fisheries amounts to 0.8% of the *nominal* GDP.

The average *value-added* per person of SI$ 156/yr (~US$ 20.7/yr) (Table 12) is low compared to the annual GDP per capita of US$ 2,428/yr. However, households' engagement in fisheries can change substantially and the annual value per person includes households that do not fish at all.

Uncertainty

The first source of uncertainty is from the estimate of CPUE. Unfortunately neither the Census nor the HIES provide information on catch per person or per household. Therefore to estimate the CPUE, the average of four villages sampled by the PROCFish project was adopted. The selection of the villages was intended to be representative of the national average (Pinca et al. 2009). However the figure may overestimate the national average because one of the criteria for the selection is that the villages had active reef fisheries. Moreover, this estimation method does not capture the likely large differences among provinces given that fishing traditions and practices differ substantially from area to area.

Other sources of uncertainty include the calculation of how often households go fishing, the fishing costs and price of fish. See Section 6.1.4 for more details.

A source of uncertainty particular to commercial inshore fisheries is regarding the proportion of fish sold in local markets (within the province) versus in the main markets of Honiara. Given the lack of information regarding this point we assumed that fishers from provinces outside Guadalcanal sell 50% of their products at local markets and the other 50% at the main three markets of Honiara. This assumption may bias the final value because the catches sold in other provinces might be less profitable than catches sold on local markets.

Given the different sources of uncertainty, it is not possible to say whether our final result is overestimated or underestimated. Dalzell et al. (1996) and Gillett and Lightfoot (2001) estimate catch from coastal commercial fisheries at 1,150 tonnes and 3,200 tonnes, respectively, compared to 24,410 tonnes estimated here. Certainly, given the increase in population over the last 15 years, estimations from Dalzell et al. (1996) and Gillett and Lightfoot (2001) should be adjusted. However, the difference between the adjusted quantity (4,236 tonnes[12]) and our estimation is still substantial. Local expertise suggests that our estimates are more likely to be correct (R. Sulu, Pers. Comm.)

12 This figure has been adjusted using population growth (17%) as an inflator assuming that commercial fisheries catches per person have remained constant over time.

Sustainability

The biological and social survey conducted by PROCFish in 2009 indicated that at the four selected sites, there was high pressure on marine resources (finfish, invertebrates and shellfish). The drivers of this pressure were population density, high fish consumption in coastal villages and the continued use of destructive fishing practices such as dynamite and fish poisoning. These pressures are likely to increase given the rapid population growth in Solomon Islands (Pinca et al. 2009).

The disaggregation of the results by province provides an indication of the level of exploitation of fisheries in Solomon. In particular, the *value-added* per hectare of reef per year is a rough measure of the intensity of fishing activity per province (Table 12). According to this measure the provinces that have the highest catch per kilometre of coastline are Guadalcanal (SI$ 2,836/ha/yr, ~US$ 377/ha/yr) and Malaita (SI$ 746/ha/yr, ~US$ 100/ha/yr), while the lowest are Isabel (SI$ 78/ha/yr, ~US$ 10/ha/yr) and Temotu (SI$ 131/ha/yr, ~US$ 17/ha/yr) (Table 12).

At a first glance, the comparison between average *value-added* per hectare of reef of subsistence fishing (SI$ 2,523/ha/yr) and of commercial inshore fisheries (SI$ 401/ha/yr) might suggest that the commercial fishery is less intense and potentially more sustainable. However, this difference is due to the different profitability of the two fisheries. The comparison between raw measures such as catches per hectare for subsistence fishing (192 kg/ha/yr) and commercial fisheries (139 kg/ha/yr) do not show such a substantial difference.

It is not surprising that these measures correspond roughly to the density of population (Table 3) confirming that population density is a driver of high pressure on marine resources as previously discussed for subsistence fisheries.

A high proportion of catch per kilometre of coast may correspond to lower catch per person as people fish less frequently due to high fishing pressure and depleted resources. The only province to show this trend is Malaita where there was very high *value-added* per hectare of reef (SI$ 746/ha/yr), but the lowest *value-added* per person (SI$ 88/yr) (Table 12).

From a management perspective, there are few interventions by the government in inshore commercial fisheries. The main interventions, such as periodical bans, focus on the management of export species (e.g. *bêche-de-mer* and live reef fish fishery) or aim to encourage the development of a local processing industry, such as the introduction of higher export taxes on raw trochus (Gillett 2011).

Distribution

The total volume of catches of inshore fisheries in Solomon Islands is 24,410 tonnes, which amounts to 41% of the total inshore catches. The *value-added* per person (SI$ 247) is much lower than that for the subsistence fisheries (SI$ 898).

This low *value-added* per person is driven by the high costs of transporting and selling the fish at the market of Honiara; it substantially reduces the *profit* margins of fishers. The *value-added* is much higher in Guadalcanal because fishers do not have transport costs. The results are likely to be biased because it is assumed that the only markets where fish is sold are in Guadalcanal, instead of considering fish markets from all provinces. The Hapi Fish data project is currently collecting data in fish markets from other provinces. In the future, this will allow a more detailed analysis.

Given that exploitation of marine resources is higher in densely populated areas, the sale of fish imported from outer provinces (such as Isabel or Choiseul) might help to reduce overexploitation in Guadalcanal and Malaita. However, the results of the analysis show that profitability of this type of fishery is low due to the high transportation costs.

6.2.1.2 BÊCHE-DE-MER

Identify

Sea cucumbers are echinoderms that move slowly across the sea bottom, consuming dead and decaying sea matter. Sea cucumbers are important for decomposition of waste. Sea cucumbers, after they are dried, for export, are a product referred to by the French name, *bêche-de-mer*. Sea cucumber harvesting is an easy-access industry. It requires very little technology and minimal capital investment. Sea cucumbers can be harvested by divers or simply collected by individuals wading through lagoons, particularly at low tide. Because these slug-like invertebrates cannot swim, they are particularly easy to catch, requiring nothing more than hands and perhaps a snorkel mask.

Solomon Islanders rarely consume *bêche-de-mer*. In North Malaita consumption of *bêche-de-mer* has been reported, but it is still considered a sporadic practice (Kinch et al. 2008). Instead, there are 22 species that are caught by artisanal fishers and sent to different countries in Southeast Asia where *bêche-de-mer* is considered a delicacy (Holland 1994). The three species with the highest prices worldwide are sandfish (*Holothuria scabra*), white teatfish (*H. uscogilva*) and prickly redfish (*Thelenota ananas*). Within Solomon Islands, white teatfish is particularly abundant at Ontong Java (Richards et al. 1994).

This type of fishery has a long tradition in the Western Central Pacific region and dates from 1844 in Solomon Islands (Kinch et al. 2008) with exports directed to Australia. The sea cucumber fishery in Solomon Islands peaked in 1992, with 715 tonnes of exports. Populations of *bêche-de-mer* started to decline in the late 1990s and early 2000s, and in 2004 exporters did not renew their trading licences (Ramofafia 2004). This led to a government moratorium on exports in December 2005 which is occasionally lifted for short periods. In 2007, for example, the moratorium was lifted for humanitarian reasons immediately after Solomon Islands was hit by a tsunami.

Quantify, value, uncertainty and distribution

Due to the lack of information regarding the costs of collecting *bêche-de-mer*, this report provides information on catch and value based on data provided by the MECDM.

There were highly fluctuating catches from 1999 to 2003 followed by a steep decrease in 2004 and 2005 (Table 13, Figure 6). A ban was introduced at the end of 2005, due to the high pressure on the fishery and decreasing catches. The higher catches in 2007 reflect the lifting of the ban for humanitarian reasons to assist the victims of the earthquake in the western part of the country. The ban was then reintroduced in 2008 and catches decreased steeply (Table 13, Figure 6).

There is high uncertainty regarding these data. A similar study recently published by SPC on the *bêche-de-mer* fishery in Solomon Islands (Pakoa et al. 2014) reported much lower catch estimates over the same period and a record export value of SI$ 33 million in 2013 driven by the lifting of the ban and a price of *bêche-de-mer* that reached SI$ 300 per kilogram. During periods when the *bêche-de-mer* fishery is banned, there is high incentive for illegal fishing. Despite the difficulties in controlling illegal activities, on several occasions the MFMR has seized large quantities of *bêche-de-mer* stockpiled by an export company in Honiara (Hilly et al. 2010). For these reasons, catch estimates from 2006 and 2012, when the fishery was banned, may be underestimated.

TABLE 13 • Catch and value of bêche-de-mer fishery, 1999–2010

Year	Volume (t)	Price (SI$/kg)	Total export value (SI$ '000)
1999	375	5	3,913
2000	160	23	6,892
2001	374	13	8,527
2002	173	12	3,371
2003	408	6	3,542
2004	171	24	602
2005	983	53	711
2006	0.1	87	12
2007	223	41	11,066
2008	0.119	211	28
2009	20	38	812
2010	13	49	685

Note: values are adjusted to 2010 prices.

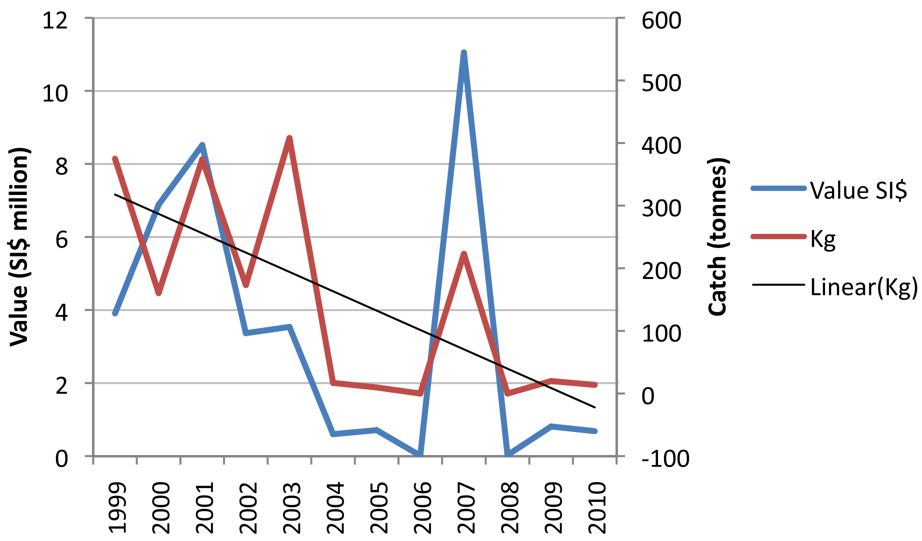


FIGURE 6 • Catch and export value of bêche-de-mer, 1999–2010, in 2010 prices

Sustainability

Bêche-de-mer catches in Solomon Islands have been declining since the 1990s (Figure 6). The high demand for these products and persistent fishing pressure are the main drivers of this declining trend and a great challenge for management (Pakoa et al. 2014). Biological surveys conducted across different provinces in 2011 and 2012 confirm the poor state of *bêche-de-mer* resources, which is in line with the decrease in exports. Sea cucumber stocks are currently in low densities and many high-value species are becoming rare. Of the 27 species of sea cucumbers recorded from Solomon Islands, fewer than 19 species were present at the sites surveyed (Pakoa et al. 2014).

The pressure on this resource is also confirmed by a biological survey conducted by the PROCFish project that found low densities of *bêche-de-mer* at all four sites (Pinca et al. 2009).

Table 14 presents densities of the three main *bêche-de-mer* species (brown sandfish, lollyfish, white teatfish) at sites in eight of nine provinces in Solomon Islands using data from Pakoa et al. (2014). Central Province has the highest concentration of brown sandfish and white teatfish, while Isabel has the highest density of lollyfish. Malaita supports the lowest densities of all three main *bêche-de-mer* species. It is important to note that these results are only indicative as the survey sites are not representative of the entire provinces.

TABLE 14 • Number of three main species of bêche-de-mer by province

Province	Population	Sites	Brown sandfish	Lollyfish	White teatfish	Number of species
Central	26,051	Ngella MPA Ngella non-MPA	285	169	15	20
Choiseul	26,372	Tapazaka Taro	16	267	10	15
Guadalcanal	93,613	Marau MPA Marau non-MPA W. Guadalcanal MPA W. Guadalcanal MPA	17	298	14	20
Isabel	26,158	Kia Tatamba	24	402	8	16
Makira-Ulawa	40,419	Star Harbour Ugi	11	199	12	16
Malaita	137,596	Central Malaita	3	69	0	10
Rennell and Bellona	3,041		NA	NA	NA	NA
Temotu	21,362	Reef Islands Santa Cruz	102	138	6	17
Western	76,649	Rarumana Chubikobi	219	52	14	17
Honiara	64,609					

NA not available

Ensuring that this resource is properly managed to avoid depletion is of primary importance for the population of Solomon Islands. With average export value of SI$ 4.47 million/yr, the *bêche-de-mer* fishery is an important commercial fishery. However, in contrast to the offshore tuna fishery, which benefits only a small proportion of the population, the *bêche-de-mer* fishery is more accessible and provides a cash income opportunity to households living on the coast far from the main cities.

Several attempts have been made to increase the sustainability of this fishery. The first step has been the national bans lifted periodically starting from 2006. In addition, in the past, WorldFish had a reseeding programme and the Ministry of Fisheries and Marine Resources are doing work on this as well. At least one community, in Ontong Java, is practicing traditional management through seasonal closures (Pinca et al. 2009).

These measures are certainly a positive step, but need to be strengthened. Pakoa et al. (2014) suggest that the current ban should be implemented more effectively and lifted only if there is evidence of increases in stock. Given that *bêche-de-mer* is a very valuable good, the incentive for illegal harvesting is high. More thorough and frequent controls of ships landing in Solomon Islands could be an effective deterrent for illegal fishers and penalties could provide some resources for monitoring. Other urgent management measures suggested for this fishery are limiting the number of exporters, introducing restrictions on fishing gears and permissible list of species for harvest together with restrictions on harvestable size and weight (Pakoa et al. 2014).

6.2.1.3 TROCHUS SHELL

Identify

The trochus is a medium to large sea snail that is found in reef areas of tropical and subtropical waters between the eastern Indian Ocean and the western Pacific Ocean (Kitutani and Yamakawa 1999). It is an important resource for Solomon Islanders because it is relatively easy to harvest and the shell is non-perishable, which is essential in rural areas where transportation services and storage facilities are irregular or absent. Trochus is sent from throughout the country to buyers in Honiara. It is commercially exploited mainly for its shell, which is processed into high-quality buttons while the meat is highly regarded as a food by locals (Lasi 2010). The fishery has been active since the 1950s and was, at the time, the second highest value export commodity after copra (Van Pel 1956a).

Quantify, value, uncertainty and distribution

No data on trochus catch or harvesting costs are available. The best source of data on this fishery is MECDM figures on exports from 1999 to 2010 summarised in Table 15.

TABLE 15 • Trochus catch and value, 1999–2010

Year	Amount (t)	Gross value (SI$ '000)
1999	201	4,906
2000	542	2,043
2001	146	3,888
2002	126	2,073
2003	431	1,340
2004	175	700
2005	557	2,043
2006	529	771
2007	174	3,699
2008	89	1,885
2009	21	409
2010	91	1,848

Note: value of catch is adjusted for *inflation* to 2010 prices.

There is high variation in catch from year to year (Table 15; Figure 7), but the trend line in Figure 7 suggests that average catches have been declining over time. Most of the trochus is exported; therefore, these values in Table 15 may be close to the total value of catches. Note that these data do not take into account the value of the benefits provided by the meat of trochus that is consumed locally and of the shells that are not exported, but used in traditional gift giving or in craft and jewellery sold locally in the central Honiara market.

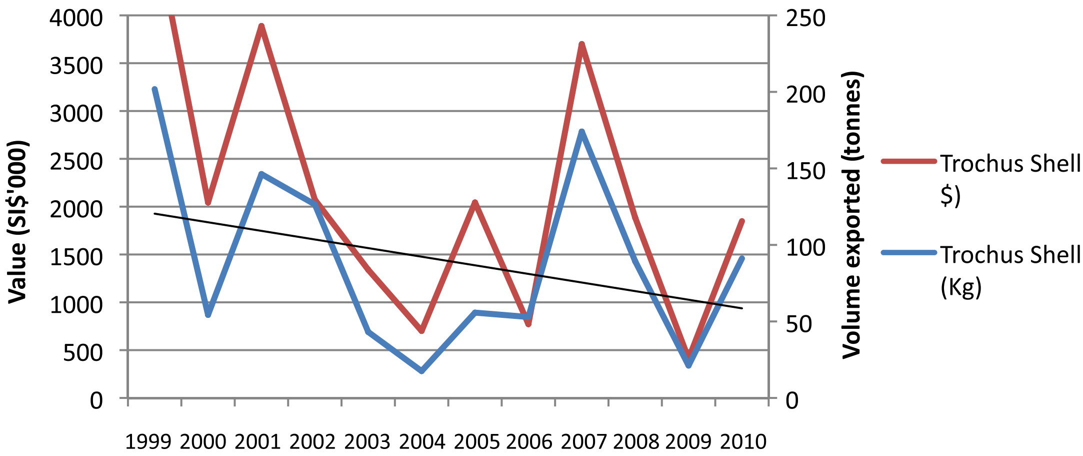


FIGURE 7 • Volume (blue) and value (red) of trochus exports, 1999–2010

Trochus harvesting is not often mentioned in valuation studies nor in reviews of Pacific Island fisheries and its importance is underestimated especially in Solomon Islands. The average value per year of trochus exports in the period from 1999 to 2004[13] was SI$ 2.49 million/yr (~US$ 331,930/yr), approximately half the value of *bêche-de-mer* exports of SI$ 4.47 million/yr (~US$ 596,066/yr). The *bêche-de-mer* fishery is regarded in the literature as a fundamentally important fishery for the economy of Solomon Islands.

Sustainability

Figures on trochus exports suggest that this fishery is under high pressure. In 1954, trochus exports were 715 tonnes/yr (Van Pel 1956b). In the 1980s the average export volume was 440 tonnes/yr, while in the 1990s exports dropped sharply to 104 tonnes/yr (Pinca et al. 2009). MECDM figures on exports in the first decade of 2000 indicate a slight increase of average catches to 127 tonnes/yr.

As for the case of *bêche-de-mer*, the high value of trochus and its relatively easy harvesting makes it particularly vulnerable to overexploitation. The survey conducted by the PROCFish project found that the density of this resource was on average only 11 individuals/ha in areas where the trochus fishery was particularly developed (Chumbikopi, Marau, Sandfly and Rarumana) (Pinca et al. 2009).

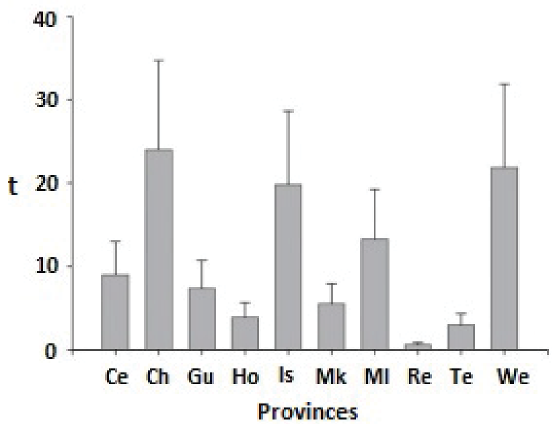


FIGURE 8 • Average annual production of trochus per province, 2000–2006. Source: Lasi (2010).

Ce = Central Province, Ch = Choiseul, Gu = Guadalcanal, Ho = Honiara, Is = Isabel, Mk = Makira, Ml = Malaita, Re = Rennell, Te = Temotu and We = Western Province

Choiseul, Isabel and Western provinces are the highest producers of trochus, while Rennell, Temotu and Guadalcanal produce the least (Figure 8). Unfortunately these data do not provide information on level of exploitation as they are not coupled with data on area of reef.

To stop the decline of trochus stock, Lasi (2010) suggested an immediate ban of its export that could be lifted only if densities reach 200–300 shells/ha. The collection of juvenile shells smaller than 8–12 cm should be prohibited (Lasi 2010).

13 Note the comparison can only be made in the period 1999–2004 because the ***bêche-de-mer*** fishery was banned in 2005–2010.

6.2.1.4 AQUARIUM TRADE

Identify

In addition to Solomon Islands' diverse seafood exports, the country exports tropical fish, invertebrates and coral for display in aquariums. This type of fishery dates back to the mid-1970s in the country. The production is mainly directed to foreign markets and Hong Kong is a primary destination for this export.

Fishing methods for live reef fish for aquariums range from hand catch with micro spear or iron bars, to hook and line and in some cases destructive techniques such as the use of cyanide (Sadovy and Vincent 2002). Slowly, more sustainable methods have been introduced in the Pacific such as light traps and crest nets (Hair and Doherty 2003).

The Nggela Islands (Central Province), Marau Sound (Guadalcanal) and the area around Honiara are the main harvesting sites for coral for the aquarium trade (Lal and Kinch 2005). Fewer than 50 villagers are involved in supplying the main exporting companies.

Although the fishing methods are simple, this type of fishery requires relatively high investment in technology to store and transport the fish alive. This makes it difficult for local people to participate in this fishery and therefore, the fishery provides limited benefits for locals. Production is usually concentrated within a few foreign companies or joint ventures and the benefits that Solomon Islands receive from this fishery are limited to the licences that these companies need to operate and taxes paid to the government. Some of the main operators exporting live reef fish, in 2015, are Philma Export Fisheries, Pacific Suppliers Ltd. and Williams International (Johnston and Yeeting 2006), while coral exporters include Wisdom Enterprise, Solomon Binu Ltd. and Sea Abundance.

Quantify, value, uncertainty and distribution

No data on aquarium trade catches and harvesting costs are available. The best source of data on this fishery is MECDM figures on exports 1999–2010 (Table 16).

TABLE 16 • Number and value of aquarium trade products, 1999–2010 (2010 prices)

Year	Live corals		Dead corals		Aquarium fish		Invertebrates (sea anemones)		Gross value SI$'000
	Number '000	Value SI$'000	Number '000	Value SI$'000	Number '000	Value SI$'000	Number '000	Value SI$'000	
1999	56	494			93	808	2	122	1314
2000	51	381			131	546	16	57	986
2001	59	432			137	748	30	115	1296
2002	32	227			49	264	12	42	534
2003	32	262			78	449	14	58	769
2004	28	176			28	142	9	34	353
2005	71	591			98	467	10	41	1100
2006	98	1,401	49	417	127	797			2198
2007	139	1,613			96	486			2099
2008	52	626			56	238	95	42	907
2009	465	365	19	19	68	266	7	41	673
2010	97	2,203			76	281	10	38	2523

The value of the export of this fishery for the period 1999–2010 was on average SI$ 1.22 million/yr (~US$ 162,520/yr) (Table 16). The value of the aquarium fishery is 57% of the value of the trochus industry and 37% of the value of the *bêche-de-mer* fishery. This fishery provides limited benefits to the local population. In the case of coral trade, local fishers are paid on average SI$ 1.99/piece by one company and SI$ 4.02/piece by the other (2005 prices) (Lal and Kinch 2005). This means that Solomon Islanders received SI$ 296,175/yr (~US$ 39,450/yr) in cash from this fishery, 24% of the total export value.

However, if we take into account costs calculated by Lal and Kinch (2005) we obtain a *producer surplus* of SI$ 207,323/yr (~US$ 27,615/yr). If only 50 villagers are involved, the aquarium trade could provide up to SI$ 4,145/person/yr (~US$ 552/person/yr).

As for trochus and *bêche-de-mer*, one of the challenges of high-value export marine products is underreporting or illegal trade. In the case of the live coral or live reef fishery, this is less likely because a high proportion of these products are transported by air, making illegal export activities harder to hide. There is also uncertainty regarding the value of exports. Lal and Kinch (2005) suggested that the price of a piece of live or dead coral is on average SI$ 22, however data on exports on which our analysis is based show an average price of SI$ 7.4. Our results are based on official, published MECDM figures but data from Lal and Kinch (2005) suggest that the official values may be underestimates.

Sustainability

The volume of exports in the aquarium trade fluctuated greatly in the period 1999–2010, with no clear trend (Figure 9). Given the relatively low volume of exports (Table 16), catches for the aquarium trade alone probably do not pose a threat to reef fish and coral stocks. However, if not managed properly, the industry could become unsustainable for certain species as it targets specific fish and a high number of juveniles for mariculture. Destructive fishing practices need to be monitored and prevented.

In the case of coral trade, an alternative proposed in some studies is coral farming at a medium to large scale which could be both profitable and sustainable (Lal and Kinch 2005; WorldFish 2013).

FIGURE 9 • Value of aquarium trade exports, 1999–2010

6.2.2 OFFSHORE FISHERIES

Offshore fisheries in Solomon Islands are well developed and focus mainly on tuna although they also include other pelagic and deep-sea fish. As in other countries of the Pacific, offshore fisheries are mostly for commercial sale and mostly for export. Generally, 80% of the catches are of export quality, while the other 20% is not export quality and is sold in local markets.

The tuna fishery in Solomon Islands is the fifth largest of the Pacific Island countries in terms of catch. The tuna fishery targets the four main tuna species — skipjack, yellowfin, albacore and bigeye. Fishing techniques for tuna are mainly purse seine and, to a lesser extent, longline and pole and line.

Information on the deep-water demersal fishery was not available.

6.2.2.1 IDENTIFY

Skipjack is the dominant commercial tuna species in Solomon Islands, making up 64% of the annual catch, followed by yellowfin (25%) albacore (7%) and bigeye (4%) (Table 17).

Most tuna (87%) are caught with a purse seine that consists of large nets closed at the bottom to prevent the fish from escaping (Table 17). This fishing technique, when used with additional technologies to locate the schools, can be extremely effective, which raises concerns regarding its sustainability if used on a large scale.

Longline, which accounts for 12% of the total tuna catch, is the second most frequent fishing technique (Table 17).

This method is based on a long line baited with fewer than 100 to more than 1000 hooks at different depths. The value of catches from this method is generally much higher than fish caught with purse seine. One of the main concerns of this fishing technique is bycatch of animals including other commercial pelagic fish such as blue marlins, sharks and mahimahi, and also non-commercial and endangered species such as turtles or seabirds.

In the fisheries sector, the tuna fishery is the leading income generator for the government and tuna is the most valuable fisheries export product. The industry provides employment on fishing vessels, at landing sites and in processing facilities. Government *revenues* are generated from access fees through licensing, and also through *resource rent*.

Solomon Islands is one of Parties to the Nauru Agreement (PNA)[14], a sub-regional agreement among eight countries in the Pacific that collectively control 25–30% of the world's tuna supply and approximately the 60% of the Western and Central Pacific tuna stock. This agreement aims to sustainably manage this vast resource, mainly focusing on purse seine fishers, by using a Vessel Day Scheme (VDS). Members of the PNA agree on a limited number of fishing days for the year, based on scientific advice about the status of the tuna stocks. Fishing days are then allocated to countries which can then sell the days to the highest bidder. In this way, Pacific Islanders reap *economic benefits* from their sustainable management of tuna (PNA 2013). Currently the VDS scheme covers only purse seiners, while long liners are subject to a licence limit that has been reduced from 180 to 120 in 2015 for foreign chartered boats. In 2016 the Solomon Islands Government aims to enforce the VDS for long liners as well as purse seiners, covering 99% of the total reported catches.

6.2.2.2 QUANTIFY

In the last 15–20 years, tuna catches have been monitored extensively by governments and international organisations. Data are now more robust than for any other fishery in the Pacific and catches are measured and verified using a combination of log-books, ship captains' information and observers' estimates and the actual weight measured dockside (SPC 2014).

Longline catch is composed mainly of albacore, while the most abundant species caught in purse seines are skipjack and yellowfin (Table 17). Pole and line, which is considered one of the most sustainable fishing techniques, accounts for only 1% of total tuna catches (Table 17).

TABLE 17 • Commercial offshore tuna fishery catch (tonnes) by species and fishing gear

	Albacore	Bigeye	Skipjack	Yellowfin	Total	%
Longline (Frozen)	777	231	8	1,196	2,212	2%
Longline (Fresh)	7,984	707	86	3,259	12,036	10%
Longline (Total)	8,761	938	94	4,456	14,248	12%
Purse Seine	0	3,647	75,292	25,780	104,720	87%
Pole and Line	0	0	1,055	143	1,198	1%
Total	8,761	4,585	76,441	30,379	120,166	
%	7%	4%	64%	25%	100%	

Source: SPC 2014

6.2.2.3 VALUE

The value of this ecosystem service can be quantified by measuring the consumer and the *producer surplus* obtained from commercial fisheries according to the following equations. This method quantifies the net benefits that fishers receive from the ecosystem service.

$$\text{Producer surplus} = \text{Commercial Fishing Revenue}_{\$} - \text{Commercial Fishing Costs}_{\$}$$

$$\text{Commercial Fishing Revenue}_{(\$)} = \left(\text{Catches}_{i(\$)} \cdot \text{Price}_{i}\left(\frac{\$}{kg}\right)\right) - \text{Commercial Fishing Costs}_{\$}$$

14 Nauru Agreement Concerning Cooperation in the Management of Fisheries of Common Interest

This report adopts the values provided by the OFP-SPC database that uses prices mainly from the Japanese and Thai markets (SPC 2014). The gross value of tuna catch is provided in Table 18.

TABLE 18 • Gross value (US$'000) of tuna catch in Solomon Islands waters by method and species, 2013

	Albacore	Bigeye	Skipjack	Yellowfin	Total	%
Longline (frozen)	1,951	2,029	16	7,739	11,737	4%
Longline (fresh)	20,055	6,395	177	26,459	53,088	19%
Longline (total)	22,007	8,425	194	34,198	64,825	23%
Purse seine	0	6,324	142,452	64,541	213,318	76%
Pole and line	0	0	2,351	386	2,738	1%
Total	22,007	14,749	144,998	99,126	280,881	
%	8%	5%	52%	35%		

To value the costs of tuna fisheries in Solomon Islands we used data provided by an external consultant (R. Banks, pers. comm. 2014) that referred to the PNA (2013). Costs take into account vessel costs (including capital, labour and depreciation) and the MFMR's contribution (in management costs) to the commercial tuna fishery, and are differentiated between foreign boats from distant water fishing nations (DWFN) and foreign boats based locally within Solomon Islands (Table 19).

TABLE 19 • Costs of tuna fisheries in Solomon Islands waters by method and vessel ownership, 2013

Method	Domestic			Distant Water Fishing Nations			Foreign, locally-based		
	Cost per day SI$'000	Number of days	Number of vessels	Cost per day SI$'000	Number of days	Number of vessels	Cost per day SI$'000	Number of days	Number of vessels
Longline	0	0	0	1,203	3,900	84	1,105	1,000	5
Purse seine	0	0	0	7,407	6,500	40	4,338	29,760	150
Pole and line	9,390	540	3	0	0	0	0	0	0
Total		540	3		10,400	124		31,300	158

Source: MFMR 2014

Pole and line fishing has the highest costs, and longline the lowest (Table 19). Purse seine has high costs compared to longline but nevertheless accounts for the highest number of fishing days in Solomon Islands' water (Table 19).

The final step to value the ecosystem service of tuna fisheries to producers is to subtract the costs from the total value of the fishery. The *economic value* of the fishery amounts to US$ 221,089,000 (~SI$ 1,659,827,300) (Table 20).

TABLE 20 • Value-added of tuna catch in Solomon Islands waters (US$ '000) by method and species, 2013

Method	Albacore	Bigeye	Skipjack	Yellowfin	Total	%
Longline (frozen)	1,774	1,845	14	7,038	10,673	5%
Longline (fresh)	18,238	5,816	161	24,061	48,278	22%
Longline (total)	20,013	7,661	176	31,100	58,952	27 %
Purse seine	0	4,876	109,837	49,764	164,478	74%
Pole and line			-2,010[a]	-330[a]	-2,340[a]	-1%[a]
Total	20,013	12,538	108,003	80,534	221,089	
%	10%	6%	48%	36%		

a Note that the pole and line fishery has negative profits. This is probably due to data inconsistencies as ships would not operate with negative profits. However, the figures confirm that pole and line is less profitable than other methods as it exploits tuna stocks less intensively.

Note that even though skipjack is the main species caught in Solomon Islands (64% of the total; Table 17), its *value-added* amounts to only 48% of the total value of tuna fisheries (Table 20). The other target species have smaller catch volumes but are much more profitable.

Note that the pole and line fishery has negative profits. This is probably due to data inconsistencies because it is unlikely that ships would operate with negative profits. However, it confirms that pole and line is less profitable than other methods as it exploits tuna stocks less intensively. Labelling pole and line tuna as a sustainable fishery may enable producers to sell these products at a higher price than tuna caught with traditional fishing methods, increasing the profitability of this fishery. Recently SolTuna has started to adopt a similar marketing strategy for tuna caught under the PNA.

6.2.2.4 UNCERTAINTY

Data about tuna catches in the Pacific have been collected for more than 20 years. The quality has increased substantially during the last decade, due, in part, to the triangulation of data gathered by different methods. The OFP-SPC, the source of the dataset adopted for this report (SPC 2014), specifies that data on longline catches might be subject to a higher degree of uncertainty because they are still preliminary.

Data on costs should be used with caution because they are unpublished and unverified. This uncertainty may account for the negative *value-added* for pole and line fishing (Table 20). The accuracy of these data could not be tested by comparing with other sources as none were available.

6.2.2.5 SUSTAINABILITY

Stock assessments in the South Pacific show that stocks of skipjack, the main target species of the tuna fishery in Solomon Islands, remain in a reasonable healthy state (Rice et al. 2014). Stocks of albacore (Hoyle et al. 2012) and yellowfin (Davies et al. 2014), which account for 13% and 26% of the total catch, are considered well maintained, but the actual fishing level should be monitored given the higher exploitation level compared to skipjack. In contrast, bigeye, which accounts for 6% of the Solomon Islands tuna catch value, has a critical status. The most recent stock assessment (Harley et al. 2014) highlights that stock of bigeye has now been reduced to less than 20% of its unfished stock size.

Peaks in catches of tuna in 1998 and 2010 were followed by a fall in yields (Figure 10). Given the information available it is not possible to confirm whether this pattern is attributable to overfishing. What is evident is that the trend shows yields that are not constant and subject to frequent shocks.

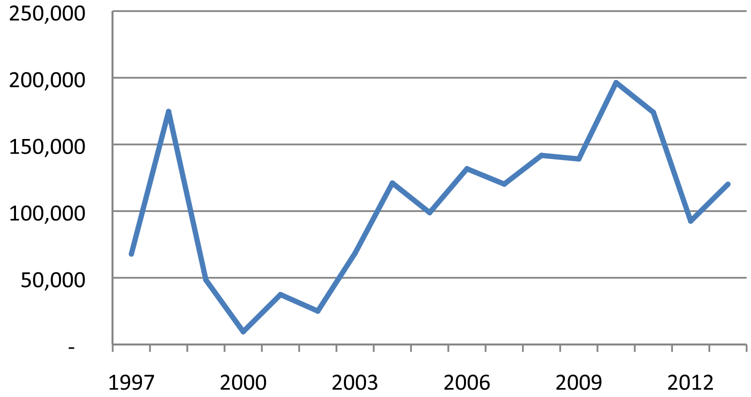


FIGURE 10 • Annual tuna catch (tonnes), 1997–2013

From a management perspective, the Fisheries Act 1998 sets the objectives of fisheries management and development in Solomon Islands which are to ensure sustainable use of the fisheries resources to achieve long-term conservation for the benefits of Solomon Islanders. In particular, the Solomon Islands National Tuna Management and Development Plan (Government of Solomon Islands 1999) established the objectives for tuna fisheries: tuna fisheries should not be exploited beyond their optimal sustainable yields, but at the same time should maximise the social and *economic benefits* for local people. This plan is currently being revised and an updated version should be published in 2015.

Since the management of highly migratory species such as tuna is a transnational issue, different international bodies have been established to collectively manage the fish stocks of the Pacific. Currently Solomon Islands is a member of the WCPFC and a Party to the Nauru Agreement (see Section 6.2.2.1).

The WCPFC was established in 2004 and comprises members from the Pacific and also from all those countries that are not from the region but are actively involved in tuna fishing in the Pacific (e.g. USA and EU). Some of its roles are monitoring, control and surveillance of fishing vessels through different methods such as compliance monitoring, high seas boarding and inspection, and a regional observer program.

These institutions and transnational policies show that the right mechanisms are in place to sustainably manage highly migratory species in the Pacific. Political will from Solomon Islands its neighbours from the Pacific and DWFN will be critical for the success of these institutions and sustainable management of offshore fisheries in the Pacific.

6.2.2.6 DISTRIBUTION

Almost all (99%) tuna fishing in Solomon Islands' EEZ is conducted by foreign fishing vessels. Foreign vessels use intensive and, in some cases, unsustainable fishing methods such as longline and purse seine, while domestic vessels rely exclusively on the more sustainable pole and line technique. This raises concerns regarding the fact that foreign nations gain most of the benefits and have the most negative impact on the tuna stocks, whereas the more sustainable domestic boats only have a minimal share of these benefits.

Figures on the amount of fish that is landed in Solomon Islands compared to that landed in foreign ports are not available. However, there is some information on the share of benefits from offshore commercial fisheries that are directed to Solomon Islands. First, for some species of tuna only a share of the catch is of export quality. For example, only 80% of catches of yellowfin tuna are of export quality and sent overseas, while the rest is typically landed locally. Second, as reported by Gillett (2009), citing the Central Bank of Solomon Islands, the total fish exports earnings for 2007 accounted for SI$ 157 million (~US$ 20.9 million), broken down into canned tuna (SI$ 43 million), frozen tuna (SI$ 102 million), frozen tuna for sashimi (SI$ 7 million), and other fish products (SI$ 5 million). Although this is only a fraction of the total value of the catches sold on foreign markets, it is still very important for Solomon Islands as it accounts for 1.9% of the total GDP of the country.

Another benefit to Solomon Islands is from the VDS scheme access fees. *Revenues* from access fees have increased substantially in the last 10 years (Figure 11). They amounted to SI$ 42 million (US$ 5.55 million) in 2005, SI$ 139 million in 2007 and 2008 (US$ 18.57 million), SI$ 127.19 million in 2010 (US$ 16.94 million), SI$ 171.1 million in 2013 (US$ 22.79 million) and SI$ 216.8 million in 2014 (US$ 28.87 million). This means that in 2013 access fees for the government accounted for 27% of *value-added* and 8% of the gross value of total tuna catches. *Revenue* from the VDS scheme accounted for 2.6% of the total GDP of Solomon Islands.

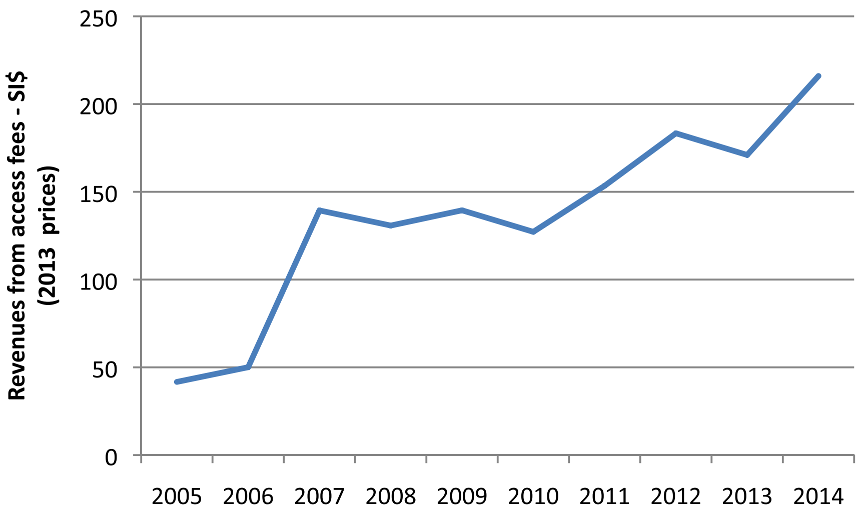


FIGURE 11 • Revenue from access fees (SI$, 2013 prices)

Other government *revenue* is also collected from licences for domestic vessels, trans-shipment fees, export and various taxes on fishing companies (Gillett 2009).

Labour in the tuna fishery sector is another form of benefit. There are relatively few local jobs on fishing vessels; however, the tuna processing industry in Solomon Islands is well developed. For example, SolTuna, formerly known as Solomon Taiyo, is the largest tuna processing and cannery industry in Solomon Islands and employs more than 1500 people located in Guadalcanal and in Noro (Western Province).

Currently one of the policies of the MFMR is to encourage foreign vessels to land in Solomon Islands by supporting the tuna processing industry and encouraging investment in this sector. The aim of this policy is to increase the share of benefits that Solomon Islanders receive from the exploitation of their tuna stocks.

6.3 MINERALS AND AGGREGATE

Sand and gravel aggregate used in concrete, roads and cinder blocks can be mined from beaches and lagoons. Concentrated mineral deposits can be found throughout the deep seafloor. Both goods are generally considered non-renewable, but their extraction may offer significant income and tax *revenue* for Pacific Island countries. Since aggregate and sand are important construction materials and minerals are important to the production of luxury goods such as cell phones and flat screen televisions, these ecosystem services potentially have substantial value to businesses and consumers. Mining, however, can also have significant *negative externalities*. *Negative externalities* are un-priced costs or harms that accrue outside of the mining industry. For example, if sand mining on a beach induces salt-water intrusion that contaminates the groundwater supply to local villages, the loss of clean groundwater is a *negative externality* of beach mining. Coastal erosion and siltation of reefs are other potential externalities of aggregate mining, which suggests that mining may be mutually exclusive with other ecosystem services such as coastal protection or fishing.

6.3.1 SAND AND AGGREGATE MINING

6.3.1.1 IDENTIFY

Concrete and asphalt construction requires sand and aggregate. This material is either quarried from rock or mined from land or sea. In Solomon Islands, in contrast to small island countries such as Kiribati or Tonga, sand and aggregates are often mined from rivers on the main islands (L. Danitofea, Ministry of Mines, Energy and Rural Electrification, pers. comm. 2014). The Ministry of Mines, Energy and Rural Electrification (MMERE) prohibits beach mining, but some minor extraction activities may be carried out by private individuals that unfortunately are not recorded in official statistics. This type of coastal mining is more likely to happen close to the main urban centres such as Honiara, because those are the only places where concrete is relatively common as building material for dwelling (16% of households) compared to the national average (3% of households)(SINSO 2009).

Coastal mining is a minor concern in the main islands because it is substituted by extraction of aggregates and sands in rivers[15], however mining may be of more concern in provinces such as Rennell and Bellona, Central, Temotu and in some islands of the Western Province. These provinces are characterised by relatively small islands that do not have large rivers where sands and aggregates can be collected in large quantities.

6.3.1.2 UNCERTAINTY

According to MMERE, coastal mining should not be a great concern for provinces such as Guadalcanal, Malaita and Isabel. Beach extraction is likely to be limited because on average only 3% of dwellings are made with concrete in Solomon Islands. What would be interesting and worth further investigation is the impact of river extraction activities on river and estuarine ecosystems.

More detailed information regarding sand and aggregate beach extraction in smaller provinces without rivers would help to value and better manage these resources.

6.3.2 DEEP-SEA MINERALS

6.3.2.1 IDENTIFY

There are three main types of deep-sea mineral (DSM) deposits: seafloor massive sulphides (SMS), cobalt-rich ferromanganese crusts, and manganese nodules. These deposits commonly contain iron, manganese, copper or zinc, and may also hold cobalt, nickel, silver and gold. Mining for DSMs is different from aggregate mining because so little

15 This extraction activity can have consequences on the river ecosystems and subsequently to marine ecosystems of estuaries and deltas if not managed sustainably.

is known about the reserves, costs of extraction and environmental externalities. There are very few deep-sea mining operations underway; most operations remain in the exploration phase. The only deep-sea mining currently occurring in the Pacific is in Papua New Guinea by Nautilus Minerals, a Canadian mining firm.

The absence of deep-sea mining operations suggests that returns on such investments are low or that risks of investment are high. However, because some minerals have become increasingly scarce in recent years (copper, for example), it is likely that interest in deep-sea mining will continue to grow. As with land-based mining, Pacific Island countries could stand to earn substantial royalties on these activities, and mineral extraction may offer significant benefits (SPC 2013).

The environmental impacts (*negative externalities*) of deep-sea mining are largely unknown. All types of deep-sea mining are likely to produce a debris plume which will disrupt species living at those depths. Benthic organisms (those that live on or near the seafloor) are likely to be disrupted and killed (SPC 2013). Mining of seamounts for ferromanganese crusts is likely to disrupt deep-water demersal species and potentially destroy suitable habitat for these slow-growing fish. Despite these probable environmental impacts, it is possible that they are less harmful than land-based mining externalities. In addition, SMS deposits that occur at vents in the ocean floor may be renewable within a human timescale, creating the potential for sustainable seabed mining.

Solomon Islands recently issued prospective licenses to Nautilus Minerals Ltd and Bluewater Metals Ltd to explore specified areas within its waters for the presence of mineral resources and feasibility of extraction. New requests for extraction licenses have been made and focus on Makira and Temotu waters and Eastern Solomon waters.

6.3.2.2 QUANTIFY

Given that only few active seabed mines exist, and that extraction companies have only started to explore Solomon Islands waters, it is not possible to quantify the potential benefits from this activity. Countries are being advised to proceed with caution and avoid taking on significant financial risk (SPC 2013).

To date the Government of Solomon Islands has received *revenue* from mining companies for prospecting licences that amounted to SI$ 2.74 million in 2012 (~US$ 364,000) and SI$ 998,217 (~US$ 132,962) in 2013.

While this an important benefit, it is likely to represent only a fraction of the value of the resource. The majority of the benefits are likely to accrue to foreign mining companies and the industries that use the minerals. The net benefit of deep-sea mining depends on the market prices of minerals extracted, the extraction costs, and the costs of externalities. Since the extraction costs and externalities are largely unknown, a true valuation of DSMs is not yet possible. Nautilus Minerals operations in Papua New Guinea may be the best reference for producer benefits, although it may be years before the benefit/cost ratio is understood.

6.3.2.3 SUSTAINABILITY

Mining must occur for manufacturers to produce many of the products on which society and most business sectors depend. Although some SMS may regenerate quickly enough to be considered renewable resources, mining is generally a non-renewable extractive industry and therefore cannot be sustained indefinitely. The ecological sustainability of mining depends on the nature of any associated negative external environmental costs. However, if *negative externalities* are minimised, deep-sea mining may be economically sustainable and efficient, particularly if it can be shown to be less environmentally damaging than land-based mining. Of greatest concern for Solomon Islands would be any potential impacts on subsistence and commercial fisheries, and also any possible indirect impacts on the private sector (especially manufacturing) that may be vulnerable to large influxes of foreign capital as a consequence of extraction activities.

6.3.2.4 DISTRIBUTION

In the near term, most benefits are likely to accrue to government in the form of licence fees, taxes and royalties. Of course, these may be redistributed to civil society by way of improved social programmes, infrastructure or other public services. There are also potential employment opportunities for Solomon Islanders. Since the mining operations are most likely 100% foreign-owned, most of the producer benefits (profit) will go to the foreign companies.

6.4 TOURISM AND RECREATION

Marine and coastal ecosystems offer a variety of passive and active recreational activities that attract local and distant visitors. Recreational activities provided by the sea, reef and beach include a wide range of pursuits including swimming, diving, snorkelling, charter fishing, fishing from the shore, recreational gleaning, kayaking, surfing, free-diving, beach activities and passive appreciation of beautiful coastal vistas. These activities can be collectively defined as marine and coastal tourism and recreation.

The participants in or consumers of marine and coastal tourism and recreation are diverse and can be from nearby communities, other parts of Solomon Islands or from other countries. Therefore, tourism and recreation can be further categorised into international tourism and domestic recreation and tourism. This distinction is made because much domestic recreation and tourism involves non-market activities, while international tourism is more closely linked to charged activities and associated expenditures. This has implications for choice of valuation methods and the extent to which value estimates can be made within this project. In this report, we consider only international tourism.

Opportunities for tourism are dependent on two things: the natural and cultural amenities that people find attractive; and the man-made amenities that support travel, accommodation and recreation. The extent to which tourism and recreation are considered ecosystem services depends on the extent that their activities depend on the natural ecosystem. Snorkelling, for example, is an activity that is almost entirely dependent on the state of the ecosystem. Individuals go snorkelling and appreciate snorkelling if there are healthy and interesting coral and fish to look at. The more interesting coral and fish there are to see, the more likely tourists will be attracted to go snorkelling. Other activities are only partially linked to the status of the ecosystem. For example, tourists sitting at a beachside bar may go to enjoy a view of an unpolluted beach, but they also want a quality drink and quality service. Furthermore, they may be largely uninterested in what is going on beneath the water surface. These differences among activities complicate the calculation of tourism and recreation ecosystem services. In short, tourism demand is associated with the quantity and quality of environmental characteristics but is also influenced by infrastructure, distance, substitute activities, and other non-environmental factors (Adamowicz et al. 2011).

6.4.1 IDENTIFY

People from around the world treasure the unique marine and coastal ecosystems of the South Pacific. White sand beaches, coconut palms, warm turquoise water, brightly coloured live coral and exotic fish — many people from higher latitudes dream of experiencing these tropical island ecosystems and make significant expenditures to do so. Because of their small size, small population and isolated locations, Pacific Island countries have very limited opportunities for generating export *revenue*. Natural beauty offers the opportunity to 'export' the service of tourism to foreigners. The Gross National Income (GNI) per capita of countries with well-developed tourism industries, such as Fiji and Vanuatu, is much higher than countries with less developed tourism sectors, such as Kiribati and Micronesia; annual GNI in Fiji and Vanuatu is $4,690 and $4,300, respectively, while in the less touristic countries of Kiribati and Micronesia the annual GNI is $3,870 and $3,180, respectively (World Bank 2012). Clearly this is not a rigorous economic analysis of the marginal *economic benefits* of tourism, but the comparison motivates analysis of the international tourism value of marine and coastal ecosystems.

Solomon Islands offer a wide range of natural beauty that differs from province to province. Marovo Lagoon in Western Province is a world class site for diving and its 700 square kilometres are home to populations of Indo-Pacific bottlenose dolphin. As one of the six countries of the Coral Triangle Solomon Islands has remarkable marine biodiversity. The shipwrecks of military vessels, submarines and airplanes represent a positive heritage for Solomon Islands from the Second World War. These are now home to corals and extraordinary marine wildlife that attract scuba divers from all around the world. Other attractions of interest for international tourism are cultural practices that are linked to marine ecosystems such as shell money-making for bride price, the artificial islands of Malaita, using conch shells for calling people together, spear fighting in Makira province and turtle-calling in other provinces.

Solomon Islands' natural ecosystems, however, are only one part of the equation. Tourism depends on a wide range of other services such as marketing, infrastructure, accommodation, transportation and communication systems that are now slowly starting to develop in the country. The lack of such services is one of the reasons why the great potential of Solomon Islands for tourism is not yet fully developed.

Hotels and tourist infrastructure are mainly concentrated in Honiara to accommodate business visitors, while the resorts close to beaches and reefs are in Gizo, Western Province. Some small-scale tourism businesses are also present in Isabel, Malaita and in other provinces. Transport both to and within the country can be an issue in Solomon Islands.

Currently it is possible to reach Honiara with a direct flight from four destinations: Port Vila (Vanuatu), Nadi (Fiji), Sydney (Australia) and Port Moresby (Papua New Guinea). Sea transport for tourists is generally not feasible given the long distances of the Pacific but cruise ships have started to visit the area almost once a month. The quality and frequency of the air transport service among the islands varies considerably, depending on destinations. Gizo, the main tourist destination after Guadalcanal, is well connected with daily flights, while other islands are difficult to reach or do not have an air transport service.

In recent years, the government has realised the potential of tourism in Solomon Islands and has started to invest in this sector as a way to diversify the economy that has traditionally been highly dependent on logging, gold mining and offshore tuna fisheries. In some cases, the government faces clear trade-offs between competing ecosystem services. Logging and mining provide benefits to producers and to workers, but, in many cases, these activities and their *negative externalities* prevent the development of a robust tourism industry and the enjoyment of related benefits from healthy ecosystems. A clear example of this trade-off is Marovo Lagoon which potentially offers great opportunities for tourism but has been impacted by logging (see Section 3.3). Thus, the question is whether to keep logging, or to invest in conservation and tourism. In situations like this, ecosystem services valuation could help the government decide, bearing in mind that even without a valuation study we know that logging and mining, if not done sustainably, only have short-term benefits, while tourism is an investment with returns in both the short and long term.

6.4.2 QUANTIFY

Solomon Islands has a small, but expanding, tourism industry. Relative to Fiji or Tahiti the tourism industry in Solomon Islands is quite small, with only about 23,925 international visitors entering each year. Of this total, 10,909 (43%) visit Solomon Islands for holiday, 11,220 (47%) for business and 2,827 (10%) for other reasons (Table 21). This is a small number of visitors compared to Fiji, for example, with more than 500,000 visitors annually (MCT 2014).

Limited statistics are available on *economic activity* from tourism. For the first time in 2013, an exit survey was conducted (MCT 2014), which estimated that the average expenditure per visit was about SI$ 21,055 (~US$ 2,804) for a trip that last on average 15 days (Table 21). The sum of tourism expenditures in 2013 was SI$ 525.45 million.

TABLE 21 • Visitor expenditure in Solomon Islands by visit type, 2013

	Holiday (43%)	Business (44%)	Other (11%)	Average
Duration of the trip (days)	13.3	17	15.3	15
Expenditure per day (SI$)	1,714	1,296	684	1,409
Expenditure per trip (SI$)	22,796	22,032	10,465	21,055
Number of visitors	10,909	11,220	2,827	n/a
Total expenditure (SI$ million/yr)	248.68	247.19	29.58	223

6.4.3 VALUE

Reefs, beaches, and ocean biodiversity all contribute, to varying degrees, to the marketability of tourism activities. This study refers to the degree of association between marine and coastal ecosystems and different tourist activities as the *ecosystem contribution factor* (ECF). The *producer surplus* value of the ecosystem services is calculated by multiplying the ECF by the difference between the tourists' expenditure and the tourism industry's costs.

$$\text{Producer surplus}_{(\$)} = (\text{Total Tourism Revenue}_{\$} - \text{Tourism Industry Costs}_{\$}) * \text{ECF}$$

The precise ECF for each tourist activity is difficult to determine. For this reason we conducted a preliminary survey (n = 42) at the airport in Honiara where we asked leaving visitors to assign a percentage (from a total of 100%) to a set of different reasons that could have motivated them to go to Solomon Islands. These preliminary results show that on average 22% of visitors chose Solomon Islands as a destination because of marine and coastal ecosystems. Therefore, we assume that the ECF is 22% and this share of the benefits from tourism can be attributable to marine ecosystems.

TABLE 22 • Value of international tourism in Solomon Islands

Total visitors (2013)	Total expenditure per day (SI$)	Average number of days	Total tourist expenditure (SI$/yr)	Benefits from ecosystem service[a] (SI$/yr)
23,925	1,409	15.3	516,134,025	118,710,826

a *Ecosystem contribution factor* 22%

Table 22 shows that the gross value of this ecosystem service is SI$ 118.71 million (~US$ 15.81 million). However, note that this value does not take into account costs of the tourism sector.

6.4.4 UNCERTAINTY

The major uncertainty for the valuation of this ecosystem service is the estimation of the ECF. Even though the result might seem reasonable, the method is not robust. Asking visitors directly to indicate the relative importance (in terms of percentages) of their reasons to choose Solomon Islands can be problematic as respondents might misunderstand the question or might not be able to estimate them. Usually more robust techniques are based on revealed preferences supported by larger amounts of data.

The second type of uncertainty arises from the size of the sample (n = 42) that is probably not representative of the visitors of Solomon Islands. Any reference to these values should include an explanation of the uncertainty around them.

In the future, tourist surveys should include some questions on the reasons for visiting Solomon Islands to facilitate a more precise estimation of this ecosystem service.

6.4.5 SUSTAINABILITY

If managed responsibly, tourism can be a lucrative and sustainable ecosystem service. Because tourists generally seek out healthy ecosystems, tourism can create an incentive to protect and even rehabilitate marine ecosystems. The case of the Marovo Lagoon is emblematic. If tourism was more developed and profitable, there would have been a greater incentive for the local government and the community to stop illegal logging and, possibly, the area could have been listed as UNESCO World Heritage site as envisaged.

However, note that tourism can also increase demand for energy and imported goods and generate harmful waste. If tourists are educated properly, direct impacts to ecosystems from snorkelling, diving, swimming and beach walking can be minimal.

Among Pacific Island countries, Solomon Islands has one of the least developed tourism industries. This can be attributed to limited transport connections with other countries. In addition, infrastructure is still developing and the ethnic tensions of a few years ago might have cast a negative image regarding the security of Solomon Islands.

Despite these challenges, Solomon Islands has great potential to develop as a tourist destination. There is a growing tourism niche for authentic culture and healthy ecosystems in tropical destinations. Being a late-comer in the tourism sector also has advantages. Solomon Islands can focus from the beginning on building a sustainable tourist industry to maximise the benefits of this ecosystem service in the short and the long term.

6.4.6 DISTRIBUTION

The benefits of tourism are split among government (tax *revenue*), business owners, employees and the tourists themselves. Producer *profit* (local businesses) and government *revenue* are benefits received by Solomon Islands. Employment, although a cost to tourism businesses, is also a benefit to Solomon Islands. International tourism *revenue* is cash flowing into Solomon Islands from overseas. Like exports, international tourism generates positive foreign exchange. Some businesses are likely to be foreign-owned, but profits may be re-invested in the country.

6.5 COASTAL PROTECTION

This section on coastal protection was summarised from Pascal (2015), a report exploring the coastal protection ecosystem service in all five MACBIO countries and prepared for the MACBIO project. For more details on the methods or results, refer to Pascal (2015).

6.5.1 IDENTIFY

Coastal protection describes the different roles that ecosystems can play in protecting people, assets and infrastructure from wave and storm damage. The two main roles identified and described here are:

1. Prevention of erosion, sediment provision and/or accretion
2. Mitigation of storm surges.

These two forms of coastal protection differ in their impacts. The first provides long-term protection against the wearing away of land and removal and deposition of sediments (erosion, accretion), while the second offers short-term protection against coastal floods and storm surges. The short-term protection happens episodically, and the damage avoided is clearly identifiable (damaged buildings, roads, crops), while the effects of long-term protection are more diffuse in time.

6.5.1.1 EROSION PREVENTION AND SEDIMENT PROVISION

Coastal ecosystems in Solomon Islands play an important role in stabilisation of shorelines. The increase of human density along coasts and the resultant increasing pressure on coastal ecosystems leads to a paradox: an increase in the need for stabilised shorelines, but a decline in natural stabilising processes.

The role of mangroves in coastal stabilisation is well known (Marchand et al. 2011; Lovelock et al. 2012). Sediment processes protect coastal soil from erosion, and in some cases permit reinforcement of shoreline materials. In the same way, seagrasses form extensive meadows in the coastal areas they colonise. Their roots and rhizomes fix the material in which they grow and their leaves slow currents, thus enhancing the stability of their sedimentary substrates. This action dissipates wave energy (up to 40% of erosive energy when seagrasses are dense; Barbier et al. 2011) and also increases the rate of sedimentation (Pearson 2001). As such, seagrass beds effectively contribute to protection against waves and limit coastal erosion.

In addition, reefs are known to contribute to beach formation, even though the processes involved are not yet well described (Pérez-Maqueo et al. 2007). Beach formation occurs with accumulation of sediments from various origins (marine or alluvial), a phenomenon known as sedimentation. Coastlines near coral reefs receive sediments from this ecosystem in the form of small dead coral particles. Accumulation on the coastline of those sediments is the source of beach formation. Sedimentary accretion also maintains and nourishes beaches, in opposition to natural or anthropogenic erosion (Huang et al. 2007).

Solomon Islands has various levels of protection against erosion due to the location and quantity of several marine and coastal ecosystems. The scope of this study was to identify all ecosystem services at a national scale and, where possible, quantify and value those with readily available data. Many authors agree that assessment of erosion prevention and sediment provision is a data-demanding exercise and requires a fine resolution of analysis (Lugo-Fernandez et al. 1998; Penning-Rowsell et al. 2003; Van Der Meulen et al. 2004). For example, on a 1 km scale, neighbouring beaches can suffer both erosion and sand accretion depending on geomorphological and biological factors (Brander et al. 2004). Although it has not been possible to precisely quantify the ecosystem service of protection against erosion, three major aspects have been identified for Solomon Islands:

1. stabilisation of shorelines, critical in high human density sites
2. beach formation and stabilisation, important in tourist areas
3. atoll formation and stabilisation, very important for atoll islands.

The role of coral reefs in processes involved in erosion protection (sedimentation and accretion) is currently less well understood than the role of mangroves. Furthermore, although some natural processes involved in erosion protection are well described, it is still difficult to quantify precisely and estimate the *economic value* of such processes.

6.5.1.2 STORM SURGE MITIGATION

This study focuses on the value of storm surge mitigation by coral reefs, which is one of the most important aspects of coastal protection provided by marine ecosystems (Laurans et al. 2013). As a point of reference, average annual direct loss caused by tropical cyclone floods in 15 South Pacific countries was calculated to be up to US$ 80 million (2009 prices) with 60% of the damage resulting from loss of residential buildings, 30% from loss of cash crops and 10% from damage to infrastructure (PCRAFI 2011).

Storm systems such as tropical cyclones and mid-latitude storms and their associated cold fronts are the primary causes of storm surges[16]. Storm surges can interact with other ocean processes such as tides and waves to further increase coastal sea levels and flooding, and have maximum impact when they coincide with high tide. Breaking waves at the coast can also produce an increase in coastal sea levels, known as wave setup. Storm surges occurring at higher mean sea levels will enable inundation and damaging waves to penetrate further inland, which would increase flooding, erosion and damage to built infrastructure and natural ecosystems. The climate change effect of rising mean sea levels will be felt most profoundly during tsunamis or extreme storm conditions (CSIRO and Australian Bureau of Meteorology 2007).

Coastal bathymetry (the shape and depth of sea or ocean floor), the presence of bays and headlands and the proximity of other islands also affect the height of storm surges. Wide and gently sloping continental shelves amplify storm surges, while bays and channels can funnel and increase the height of storm surges.

Coral reefs, seagrass and mangroves provide protection against waves by forming barriers along the coast. As a result, lagoons, which are protected by barrier reefs, are relatively calm areas that provide multiple ecosystem services (e.g. biomass production and scenic beauty). Several studies have shown that reefs act in a similar manner to breakwaters or shallow coasts (Lugo-Fernandez et al. 1998; Brander et al. 2004; Kench and Brander 2009). They impose strong constraints on the swell of the ocean, resulting in transformation of wave characteristics and a rapid attenuation of wave energy.

Waves formed by the wind store a large part of their energy at the surface, and this force can be absorbed by fringing reefs and reef crests, sometimes up to 90% at low tide (Lugo-Fernandez et al. 1998). The degree of energy absorption is highly variable depending on the type of reef, the depth and the waves (Kench and Brander, 2009). The role of coral reefs and mangroves in coastal protection is difficult to isolate from other variables and, in fact, a combination of factors impact on the level of protection provided. The primary factors influencing attenuation of wave energy are:

1. bathymetry (shape and depth of sea or ocean floor)
2. geomorphology (soil origin and composition)
3. topography (coastal and inland surface shape, as well as shoreline indentations)
4. biological cover (presence of other ecosystems in the coastal area) (Burke 2004).

Few studies have focused on isolating the specific role of coral reefs within this combination of factors (Badola and Hussain 2005). In addition to the complexity of quantifying the specific contribution of coral reefs to coastal protection, an analysis by Barbier et al. (2008) found that the relationship between reef area and this absorption process was nonlinear. Similar nonlinear effects have been measured for the effect of mangroves on wave height. Waves of 1.1 m in the sea are reduced to 0.91 m in the mangrove forest if the forest has an extension of 100 m. The wave continues to decline, at a slower rate, for each additional 100 m of mangrove extension inland. For a forest extending 1000 m inland, the waves would be reduced to a negligible 0.12 m[17] (Barbier et al. 2008).

6.5.2 QUANTIFY

Understanding the national climate context is one of the keys to assessing the *economic value* of coastal protection provided by coral reefs in our methodology. To estimate the total avoided damage costs per year, we evaluated the annual probability of the occurrence of extreme climatic events by using the NOAA records of historical hurricane tracks for the last 100 years (Table 23). The streamlines of mean surface wind (Figure 12) show how the region is dominated by easterly trade winds. In the Southern Hemisphere the Trade Winds blow to the north-west and in the Northern Hemisphere they blow to the south-west. The streamlines converge, or crowd together, along the South Pacific Convergence Zone. The Southeast Asian monsoon also influences much of the Melanesian subregion (Siméoni and Lebot 2012).

16 A storm surge is an abnormal rise of water generated by a storm, over and above the predicted astronomical tide.

17 In addition, some studies have shown that the extent of reefs or mangrove may not be the main factor influencing the reduction of damage on the coast in the case of tsunamis (Done et al. 1996; Greer Consulting Services 2007; Pérez-Maqueo et al. 2007).

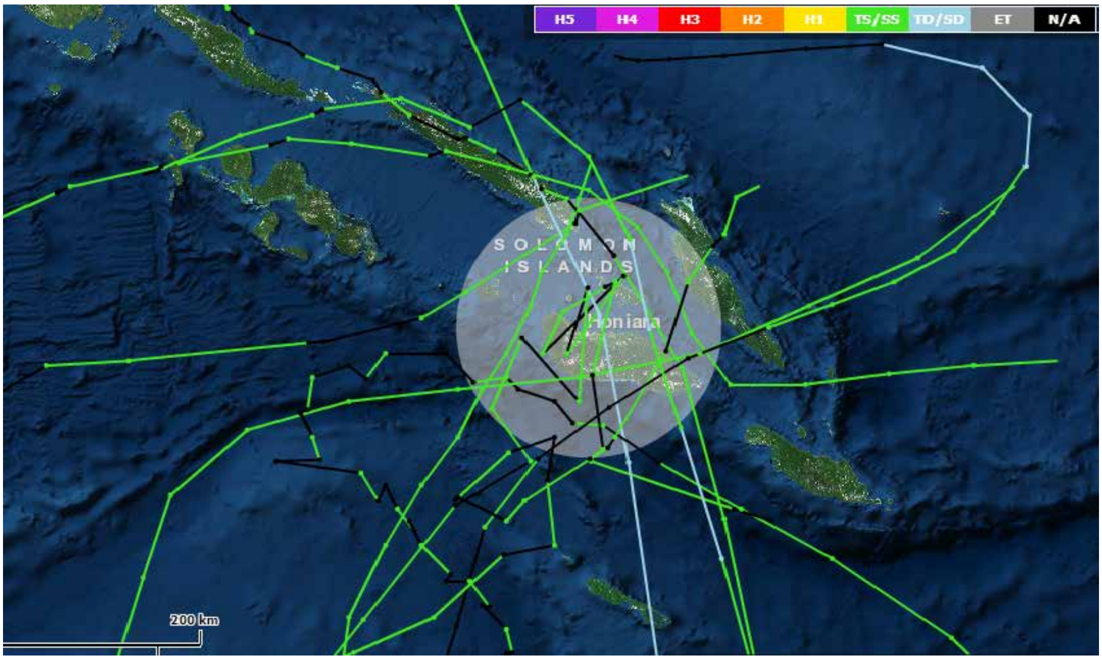


FIGURE 12 • Cyclone tracks over Solomon Islands since 1940. Source: NOAA Coastal Services Centre

TABLE 23 • Extreme climatic events in Solomon Islands since 1940

Category	Count
Category 5 cyclone	0
Category 4 cyclone	0
Category 3 cyclone	0
Category 2 cyclone	0
Category 1 cyclone	0
Tropical/subtropical storm	10
Tropical/Subtropical depression	1
Extratropical storm	0
Unknown (N/A)	0

Source: NOAA, Coastal Services Centre

Due to lack of data for other islands, our analysis of the coastal protection service provided by coral reefs against storm surge damage focuses only on Guadalcanal. Around 20% of the Solomon Islands population lives on Guadalcanal. In addition, Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI) data were available and most of the determining factors were considered homogeneous for this island.

6.5.2.1 COASTAL PROTECTION INDEX

Two methods can be used to assess the role of coral reefs[18] in coastal protection: methods based on biological properties of reefs, and methods based on physical and mechanical properties of the reefs. Due to the large quantity of information required for the biological method, and the requirement for small study areas, we chose to use a physical and mechanical model for our evaluation. One of the main limitations of such models is that we were not able to assess the true relationship between coral mortality and its role in loss of the coastal protection service.

18 Three major ecosystems contribute to coastal protection: coral reefs, mangroves and seagrasses. Nonetheless methodologies to assess ***economic impacts*** of mangroves and seagrass in terms of coastal protection are not yet consolidated (Huang et al. 2007; Pérez-Maqueo et al. 2007; IFRECOR 2011; Pascal 2014), the specific role of those ecosystems is not monetarised in the present study; they are only used in the coastal protection index as one of the main factors contributing to coastal protection.

The model used for this study scores coastal stability based on seven physical characteristics (Table 24). These physical characteristics were given a score between 1 and 5 and the average was calculated to produce a unique index value for each segment of shoreline: the coastal protection index.

The two GIS data layers used for this analysis (i.e. type of reefs, area and distance to the coast) were sourced from the Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI) with the Pacific Community (PC) and topographic reefs and coastline data from the Ministry of Lands, Housing and Survey in the Solomon Islands.

TABLE 24 • Calculation of the coastal protection index based on characteristics of the coastline

Factor	Score				
	Very strong	Strong	Medium	Low	Null
	5	4	3	2	1
Geomorphology	Rocky shore	Mix of rocks/ sediments/ mangroves	Mangroves	Sediments	Beaches
Coastal exposure	Protected bay	Semi-protected bays	Artificial reefs	Low protected bay or coast	No protection
Reef morphology, area and distance to coastal physical structure	Continuous barrier (> 80%) close to the coast (<1 km)	Continuous barrier (> 50%), patch reef, close to the reef	Fringing reef (width > 100 m)	Coral formation discontinuous	No reef
Inner slope, crest width	Very favourable conditions (gentle slope, large crest width)	Favourable conditions (slope, large crest width)	Favourable conditions (at least one condition: slope, crest width)	Reduced favour-able conditions (strong slope, re-duced crest width)	None
Platform slope	6–10%	2.5–6%	1.1–2.5%	0.4–1.1%	< 0.4%
Mean depth (< 1 km from the shoreline)	< 2 m	< 5 m	> 5 m	< 10 m	< 30 m
Other ecosystems	Mangroves and seagrasses > 75% coastline	Mangroves and seagrasses > 50% coastline	Mangroves and seagrasses > 25% coastline	Mangroves and seagrasses < 25% coastline	None

Geomorphology: The shoreline of Guadalcanal is defined by soils of sedimentary origin. The score for the factor geomorphology for the entire island is low (2).

Coastal exposure: Guadalcanal does not have any particular shoreline features (e.g. bays) that reinforce coastal protection. However, the coast is not completely linear around the island, so the score for coastal exposure is low (2).

Reef morphology, area and distance to the coast: Both barrier and fringing reefs are present in Guadalcanal. However, neither is continuous around the island. They are located at the west and east ends of the island. Honiara, the main city of the country, is unprotected by any reefs. The score for reef morphology, area and distance to the coast is low (2), due to the absence of reefs in the most inhabited area of the island.

Inner slope, crest width: the reef crest is relatively narrow (10–25 m), while the inner slope is medium or absent. Due to the discontinuity of reefs around the island, the score for inner slope, crest width, is low (2).

Platform slope: there is no lagoon in Guadalcanal, so the deep ocean is directly adjacent to the shore; the platform presents an important slope. The score for platform slope is strong (4).

Main depth (1 km from the shoreline): deep ocean is near the shoreline, so the main depth is greater than 30 metres less than 1 km from the coast. The score for main depth is null (1).

Other ecosystems: Few mangroves are present in Guadalcanal and official data with the precise location of mangroves along the shoreline was not available. Without more data, the score for other ecosystems was considered low (2) for Guadalcanal.

The coastal protection index is summarised in Table 25.

TABLE 25• Coastal protection index for Guadalcanal

Factor	Coastal protection score, Guadalcanal
Geomorphology	2
Coastal exposure	2
Reef morphology, area and distance to the coast	2
Inner slope, crest width	2
Platform slope	4
Main depth 1 km from the coast	1
Other ecosystems	2
Average	**2**

6.5.2.2 MAIN NOTABLE ASSETS AT RISK

We assessed the number, type and location of residential buildings and hotels at risk from coastal flooding and tsunamis. No robust information related to other construction works, such as public buildings and infrastructure (e.g. roads, bridges and airports) was available. Agricultural crops were also not included in the study, due to the absence of intensive crop production in the areas at risk. Data on indirect tangible damage (e.g. loss of tourism *revenue*, emergency costs, traffic disruption) were also unavailable.

Main cities and tourism: the main city in Guadalcanal is Honiara, the capital city of the country. Hotel development in Guadalcanal (and more generally in Solomon Islands) is not advanced. The four identified hotels in Guadalcanal (one four-star, three three-star) are in Honiara.

6.5.3 VALUE

The method used to value the service of protection against storm damage by coral reefs is *the avoided damage cost method*. First the assets protected are identified and quantified. Then, the *ecosystem contribution factor* of coral reef and associated systems is applied. Finally, the ecosystem service is valued in terms of the cost of damage avoided. One of the main challenges of this method is that coastal protection against waves is a complex process, incorporating many factors such as geomorphology of the coast and the presence of other ecosystems. The identification of the contributing role of each of the different factors is a challenging task and is outside the scope of this study. For more details on methods, see Pascal (2015).

Similar methodologies used to value this ecosystem service have been tested on Caribbean (Burke 2004) and New Caledonian reefs (Pascal 2010).

Table 26 presents the total and annual cost of damage to human assets avoided due to the presence of reefs. The Honiara region is an area of Guadalcanal that benefits greatly from the coastal protection service, because it is the major urban centre and the location of all the hotels[19].

19 The airport and other major infrastructure (e.g. harbour) are also in Honiara.

TABLE 26 • Value of damage avoided due to the presence of coral reefs

Relative coastal protection index	0.20	Number		Unit	Currency	Total value of avoided damage		Annual value of avoided damages	
Extreme climatic event probability (100 years)	0.11	min	max			Min	Max	Min	Max
House		3955	6591	houses	US$	28,811,145	48,018,575	3,169,226	5,282,043
					SI$	216,299,887	360,499,812	23,792,988	39,654,977
Luxury hotel		10200	17000	m²	US$	1,629,960	2,716,600	179,296	298,826
					SI$	12,236,937	20,394,895	1,346,066	2,243,438
Total					US$	30,441,105	50,735,175	3,348,522	5,580,869
					SI$	228,536,824	380,894,707	25,139,054	41,898,416

6.5.4 UNCERTAINTY

This approach is exploratory. It aims to produce an overview of the quantification and valuation of coastal protection provided by coral reefs against flooding caused by storm surges. Many uncertainties are present in every step of the approach. The main sources are: the damage functions (flood damage percentage), definition of zones at risks, the data used for GIS analysis, and the database of assets and valuations of construction costs. For details, see Pascal (2015).

Our approach to defining zones at risk partly consists of counting assets at risk from satellite images, which is likely to lead to underestimates. The damage costs of flooding are therefore likely to be higher.

A standard construction cost was used across the five MACBIO countries, regardless of the type of structure and materials. Even if this standard reflects an average construction price per square metre, it is likely to underestimate the total repair cost of assets at risk.

The flood damage percentage used in the analysis came from estimates made by the US Federal Emergency Management Agency for houses in California. Houses in Guadalcanal may suffer higher rates of damage since they are generally of lower construction quality. Again, this suggests that actual damage costs may be higher than estimated.

Minimum and maximum values are presented in Table 26 to reflect these uncertainties. The minimum number of houses in areas at risk was calculated by multiplying the estimated total number of houses by a factor of 0.75, while the maximum value was calculated by multiplying the total number of houses by a factor of 1.25.

This analysis provides an overview of the role of coral reefs in the coastal protection of some built assets (residences and hotels) at risk of extreme climatic events. Many additional parameters must be taken into account to better understand the link between coastal habitats and coastal protection. The role of seagrasses, live coral cover and processes involved in erosion regulation, and impacts on other built infrastructure and crops also need to be explored to fully value this ecosystem service.

The predicted rise of extreme climatic events due to global warming will increase the annual value of damages on coastal areas.

6.5.5 SUSTAINABILITY

Coral reef, mangrove and seagrass ecosystems provide consistent coastal protection benefits indefinitely, as long as the ecosystems remain intact. Damage to reefs and mangroves from coastal development is an ongoing threat (Burke et al. 2008). The magnitude of the services could be increased in some instances by restoring blighted or damaged reefs, mangroves and seagrasses.

Climate change, in particular acidification of oceans and warmer water temperatures, could impact reefs and mangroves and threaten the sustainability of this ecosystem service. Climate change may also increase the intensity and severity of storms, increasing the importance of coastal protection services but also increasing the expected damage. Cyclone

Pam demonstrated in Vanuatu that the most severe storms will cause catastrophic flooding and erosion. It is difficult to estimate how much damage would have occurred in Vanuatu if it were not for the presence of living reef and mangrove ecosystems.

6.5.6 DISTRIBUTION

The benefits of coastal protection accrue to anyone who owns or uses property along coastal areas. The beneficiaries may be nationals, expatriate residents, or visitors. Protection of public infrastructure, such as wharfs, marinas and roads, benefits everyone who uses that infrastructure and could decrease the country's tax burden through avoided repair costs.

6.6 CARBON SEQUESTRATION

6.6.1 IDENTIFY

Carbon dioxide (CO_2) in the atmosphere causes a greenhouse effect that results in changes to the global climate, sea temperatures, and sea levels which may have deleterious effects on Pacific Island countries. In addition, CO_2 in the atmosphere is absorbed by seawater resulting in lower sea pH levels and reduced availability of carbonate ions for marine animals that make calcium carbonate shells and skeletons (e.g. shellfish and corals). This process is termed ocean acidification.

Mangroves, wetlands, seagrasses, and phytoplankton all remove CO_2 from the atmosphere and store it in their fibres, in the soil and in the ocean substrate (Howard et al. 2014). This ecosystem service is called carbon sequestration, and refers to carbon that is removed from the atmosphere and/or prevented from release into the atmosphere.

The natural growth processes of seagrass, mangroves, plankton and other plants absorb carbon from the air. Some carbon is released back into the atmosphere during cell respiration, some is added to the plant's biomass, and some is deposited into the soil or ocean substrate. Carbon stored in the biomass of mature plants is relatively constant, but can be released into the atmosphere if the plants are killed and decay or burn. Carbon stored near the soil surface may be released over time if left un-vegetated, or released quickly if disturbed (Murray et al. 2011). Both the rate at which carbon is added to biomass and substrate, and the potential release of stored carbon are important. Together they represent the net CO_2 removed from the atmosphere and prevented from release into the atmosphere.

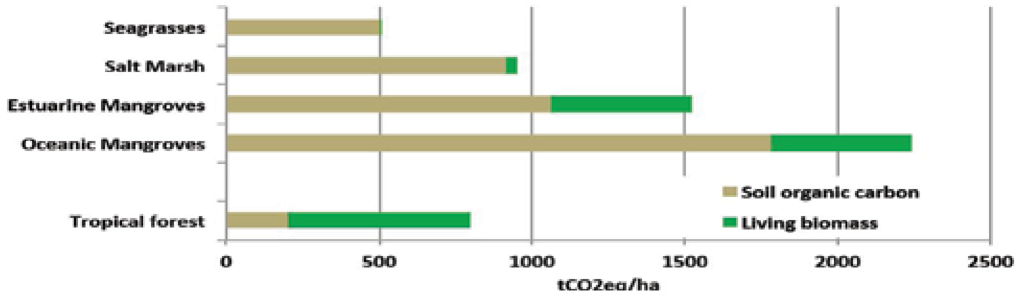
The amount of carbon that is captured and removed from the atmosphere by different plant species can be quantified in terms of a net rate of sequestration. The net amount of carbon sequestered by an ecosystem in a given time period is the sum of the rate of sequestration of each species and the release of stored carbon (Howard et al. 2014).

The magnitude of this ecosystem service is directly related to the prevalence of the ecosystems that sequester and store carbon. There are three main categories of ecosystems that sequester carbon in tropical Pacific marine and coastal environments: mangrove, seagrass, and sea algae[20]. Coastal mangroves and seagrasses are prevalent in Solomon Islands. According to the UNEP updated Landsat imagery (UNEP 2013), Solomon Island mangroves cover a total area of 56,100 hectares. Albert and Schwarz (2013) counted more than 29 species, representing 45% of the world's total. In the Pacific, only Papua New Guinea and New Caledonia have a higher number of species of mangroves.

Because the seafloor and coastal wetlands have very anaerobic soils (lacking oxygen), carbon-rich organic material decomposes very slowly. This means that these ecosystems store carbon well. Studies have shown that intact, growing mangroves and coastal wetlands sequester much more carbon each year than even tropical rainforest (Murray et al. 2011). The destruction of these ecosystems stops the sequestration process and may release the stored carbon into the atmosphere if plants and trees are burned or decomposed and if the soil is exposed to oxygen.

Figure 13 shows the relative amounts of carbon that are typically stored in different ecosystems. Oceanic (coastal) mangroves are capable of storing more carbon than any other ecosystem.

20 Salt marshes also sequester and store carbon, but are uncommon in the Pacific. Coral reef may sequester carbon under certain circumstances, but reefs are generally a net emitter of carbon dioxide (Ware et al. 1991).



Source: Murray et al. (2011)

FIGURE 13 • Carbon storage abilities of different types of habitat

Although ocean phytoplankton sequesters carbon, it is unknown if or how humans could impact this process[21]. This study focuses on the carbon sequestration benefits of seagrasses and mangroves in Solomon Islands.

It is important to note that in Solomon Islands these coastal ecosystems provide a variety of services in addition to carbon sequestration, such as food, fuel for fires, construction and fishing materials estimated between US$ 350 and US$ 1,501 per household from data collected in Malaita and Choiseul (Warren-Rhodes et al. 2011).

6.6.2 QUANTIFY

To date there has been no quantification of the carbon sequestration services provided by mangroves, tidal sea marshes and seagrass in Solomon Islands. Research has focused mainly on the status, biology and management practices in mangrove ecosystems with some minor information on seagrass.

Assessing carbon stocks and emission factors in coastal blue carbon with robust methodologies can be an expensive and very lengthy process (Howard et al. 2014). Given the scope, time and resource constraints of this study, Landsat imagery from a public global database was used (UNEP 2013) to measure the area of mangrove forests (56 100 ha) coupled with published carbon stock estimates (Murray et al. 2011). Murray et al. (2011) estimated that the living biomass of a hectare of oceanic mangroves was around 237–563 tonnes of CO_2 equivalent per hectare (t CO_2eq/ha). This value includes biomass above and below the soil. A more consistent portion of the carbon stocks is stored in the soil and is known as soil organic carbon. This can measure between 1690 and 2020 tonnes. Therefore the total amount of carbon stored in mangroves is between 1927 and 2583 t CO_2eq/ha.

If mangroves are destroyed, the total carbon dioxide at risk for release depends on assumptions about what happens to the mangrove biomass and carbon stored in the soil. The first assumption regards how much biomass carbon is released into the atmosphere when mangroves are cut down, burned, or buried. If mangrove wood is used to build houses and furniture, much of the carbon remains in the wood structures; if mangrove wood is burned most carbon is released into the atmosphere as CO_2. The second assumption is about how much carbon is released from the soil if mangroves are destroyed. We have limited our analysis to the top metre of soil, assuming carbon stored deeper than that will remain in the soil indefinitely. The greatest release of biomass and soil carbon would be in the first few years, and then gradually decrease over time. Eventually, all biomass carbon and most soil carbon may be released into the atmosphere. Because we do not know the future uses of land where mangroves are destroyed (e.g. agriculture or commercial development), we estimate the carbon released over 15 years following land-use conversion.

Following the estimates of Murray et al. (2011), we assume 75% of biomass carbon is released in the first year and the remaining 25% is released at a 15 year half-life. We assume that carbon in the top metre of soil is released at a 7.5 year half-life (i.e. 50% of the stored carbon is released in the first 7.5 years, 25% in the following 7.5 years, etc.) (Murray et al. 2011). This means that in the first 15 years, 87.5% of biomass carbon and 75% of soil carbon is released into the atmosphere, which equates to 201.4–478.5 tCO_2/ha from biomass and 1267.5–1501.5 tCO_2/ha from the soil for oceanic mangroves in Solomon Islands (Table 27). The foregone average carbon sequestration rate (6.3 t/ha/yr) is added to these annual release estimates to produce a range of carbon lost from mangrove areas over 15 years (Table 27).

21 Research on the sequestration and storage process of phytoplankton is ongoing, and trials are being conducted to attempt to increase the rate of sequestration (Reibesell 2004; Riebesell et al. 2007).

TABLE 27 • Potential carbon emissions from mangrove destruction

Source	Potential carbon emissions from mangrove destruction (t CO_2/ha over 15 years)	
	Minimum	Maximum
Biomass	201.4	478.5
Soil	1267.5	1501.5
Foregone sequestration	94.5	94.5
15 year total	1569.4	2074.5

A recent marine assessment conducted by TNC found that ten species, 80% of the known seagrass species in the Indo-Pacific region, were present in Solomon Islands. Some seagrass beds had an extension of more than 1000 ha and some meadows were found at depths up to 37 m (Green et al. 2006). These data are not complete and should be improved to allow a more precise valuation. However, the Blue Carbon Initiative estimates average sequestration rate of seagrasses to be approximately 4.4 tCO_2/ha/yr; somewhere between 0.4 and 18.3 tonnes of CO_2 per hectare are stored in biomass and approximately 500 tonnes per hectare in seagrass soils (Sifleet et al. 2011). Therefore, we could argue that carbon sequestration by seagrass is not negligible and will need to be estimated to form a complete picture of the value of this marine ecosystem service in Solomon Islands.

6.6.3 VALUE

There are two distinct approaches to valuing human benefits that result from carbon sequestration. The first approach is measuring the marketability of carbon offsets, that is, selling assurance that a carbon sequestering ecosystem will be protected from destruction and thereby reducing the amount of CO_2 in the atmosphere. This is termed the *market value* of carbon sequestration. The second approach is to measure the avoided *social cost of carbon.* The *social cost of carbon* (SCC) is the probable harm from additional CO_2 in the atmosphere. In other words, the SCC is the expected impacts of climate change. SCC is measured as the monetary value of damage caused globally by emitting one more tonne of CO_2 in a given year (Pearce 2003). The SCC therefore also represents the value of damage avoided for a small reduction in emissions, in other words, the benefit of a CO_2 reduction[22] (US EPA 2013).

Market value is an immediate and localised benefit that may accrue to those individuals who can protect an ecosystem from destruction, verify the carbon sequestration properties of that ecosystem, and sell the verified amount of carbon offset to willing buyers. Avoided *social cost of carbon* is a global value; it is a benefit that accrues to all who may suffer the consequences of climate change. The SCC more accurately represents the true benefits of carbon sequestration, but may be less interesting to stewards of carbon sequestering ecosystems who stand to gain monetarily from selling carbon offsets. When estimating the carbon offset value it is important to consider additionality, that is, how much of the carbon sequestering ecosystem would have been destroyed in the absence of the offset payment being made. Only areas that have been destroyed and can be rehabilitated or areas that are likely to be destroyed can be considered additional. In other words, it is not possible to sell a carbon offset for an area that is unlikely to be destroyed, because there is no carbon 'saved' from the atmosphere.

Carbon sequestered by mangroves and seagrass represents a reduction in atmospheric CO_2. The estimated SCC used by the US EPA and other US agencies for appraisal of emissions reductions in 2015 is US$ 61, *discounting* future damages annually at 2.5%. Using this benefit estimate, the sequestration rate of 6.3 tCO_2/ha, and the total estimated area of mangroves in Solomon Islands, the annual social benefit of sequestration from mangroves is SI$ 162 million/yr or SI$ 2,885/ha (US$ 21.56 million/yr or US$ 384/ha) (Table 28).

22 This is an average value, not a true ***marginal value***. As CO_2 levels increase, each additional unit may be more harmful than the last.

TABLE 28 • Annual social benefit of sequestration by province

Province	Mangrove area (ha)	Carbon sequestration (tCO_2/yr)	Total value (US$/yr)	Total value (SI$ /yr)
Central	2,107	13,274	809,714	6,080,952
Choiseul	8,979	56,567	3,450,587	25,913,908
Guadalcanal	1,899	11,963	729,743	5,480,370
Isabel	19,816	124,840	7,615,240	57,190,452
Makira-Ulawa	1,165	7,339	447,679	3,362,069
Malaita	12,099	76,223	4,649,603	34,918,519
Rennell and Bellona	–		–	–
Temotu	4,368	27,518	1,678,598	12,606,271
Western	5,669	35,714	2,178,554	16,360,941
Total	56,100	353,430	21,559,230	161,909,817

Isabel and Choiseul are the provinces with the highest social benefit of sequestration by mangroves, Guadalcanal and the central provinces have the lowest benefits (Table 28; Figure 14). Rennell and Bellona, a very small province in the south-east of the country, does not appear to have any mangrove forest according to the satellite imagery (Table 28) but people from Rennell say that mangroves exist at Lake Tangano. These differences in mangrove distribution among provinces can be attributed to the different geographies of the provinces.

An alternative value per tonne CO_2 that is commonly used in the appraisal of the value of carbon sequestration is the potential value of carbon offsets sold in a carbon market. Carbon market prices can be used in financial assessments of conservation or restoration projects to estimate potential *revenue* from the project. The potential value of carbon offsets is directly related to the area of mangroves and/or seagrass that can be protected from destruction or rehabilitated. Over the period 2000–2005 the average annual loss of mangroves in Solomon Islands was 1.70%/yr. In Solomon Islands this would mean a loss of about 953.7 hectares each year. Using the carbon release ranges in Table 27 and the current average market price of $4.90/$tCO_2$ (Forest Trends 2014). Solomon Islands has the potential to sell between US$ 7.333 million and US$ 9.692 million in offsets each year (~SI$ 55.059 – 72.763 million). That is US$ 7,690–10,162 (~SI$ 57,732–76,295) per hectare of mangroves protected (Table 29).

TABLE 29 • Value of potential carbon offsets by province (2014 market price)

Province	Mangrove area (ha)	Minimum value of potential carbon offsets (US$ million)	Maximum value of potential carbon offsets (US$ million)
Central	2,107	0.28	0.36
Choiseul	8,979	1.17	1.55
Guadalcanal	1,899	0.25	0.32
Isabel	19,816	2.59	3.42
Makira-Ulawa	1,165	0.15	0.20
Malaita	12,099	1.58	2.09
Rennell and Bellona	–		
Temotu	4,368	0.57	0.75
Western	5,669	0.74	0.97
Total	**56,100**	**7.33**	**9.69**

The difference between the value of carbon sequestration measured as social benefit of sequestration (Table 28) and potential carbon offsets (Table 29) is substantial, highlighting how the *willingness-to-pay* from buyers on the voluntary market still does not match the *real* benefit that avoiding the release of a tonne of CO_2 provides in terms of avoided damage from climate change. However, even a relatively small payment for this ecosystem service would be a more effective conservation incentive in Solomon Islands than no payment, as is currently the case.

This information may be useful for policy-makers to plan future conservation strategies, but also to design and identify the most suitable areas for the establishment of a payment for ecosystem services such as REDD+ or other carbon schemes.

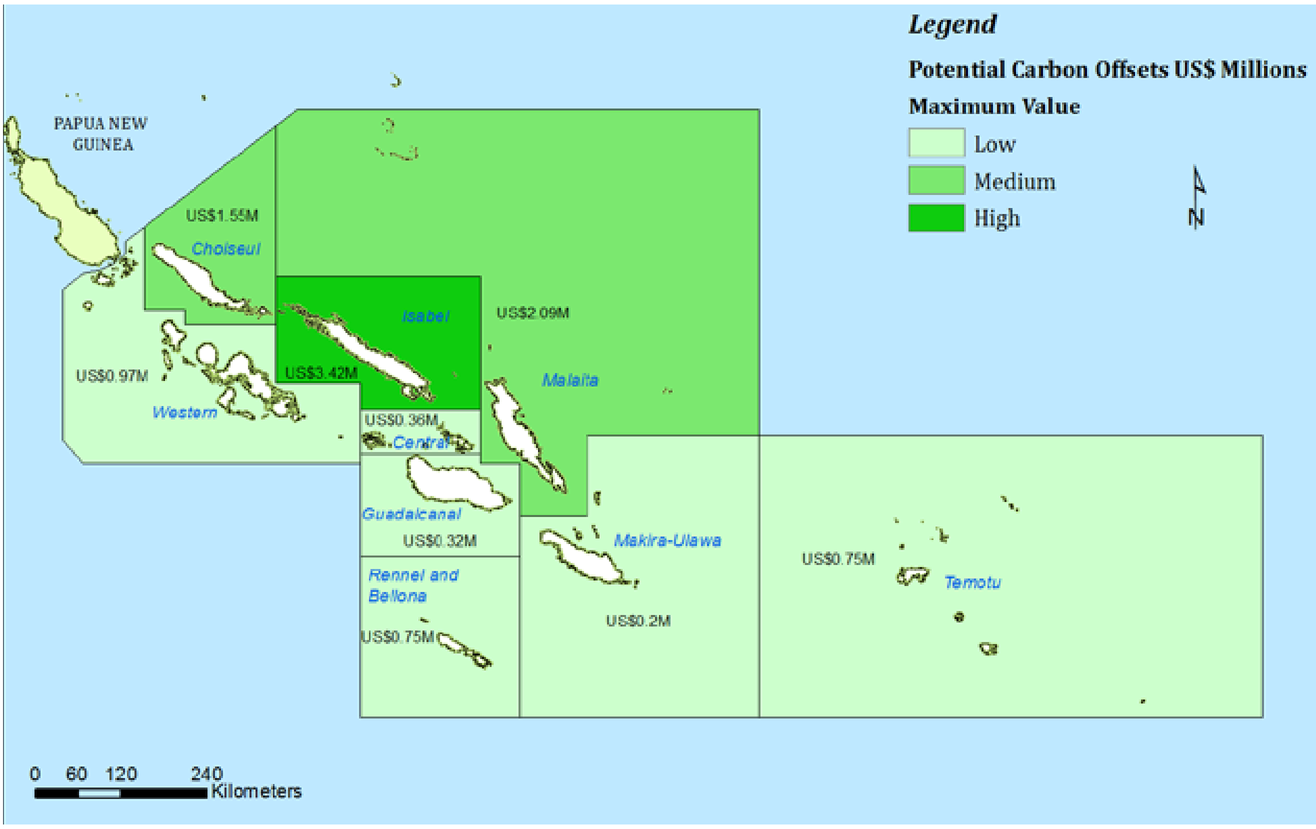


FIGURE 14 • The potential value of carbon offsets by province in Solomon Islands

6.6.4 UNCERTAINTY

Given the scope of this report and data available for the quantification of carbon sequestration by marine ecosystems, we only focused on mangroves and did not quantify the C02 contained in seagrass meadows and tidal marshes. The values, therefore, are underestimates. The method chosen for the quantification is subject to three sources of uncertainty:

- Accuracy of satellite images
- CO_2 conversion rates
- CO_2 values

The first source of uncertainty arises from satellite images that use remote sensing methods to identify mangroves forests. The best practice would be to ground truth the data by conducting field surveys.[23] This would have helped to assess whether the information overestimated or underestimate the area of mangroves.

The second source of uncertainty is the carbon sequestration rates obtained from the study by Murray et al. (2011).

23 A rough check was done to verify that the mangrove areas identified by satellite were in plausible locations. However field surveys are required to assess the accuracy of the map.

These conversion rates depend on the characteristics of the forest such as age, species, and whether they are estuarine or oceanic mangroves. Robust methodologies do not only involve field surveys, but also laboratory analysis to identify the actual CO_2 contained in the biomass and in the soil.

The third source of uncertainty is related to the price of carbon. There is animated debate about methods for calculating the *social cost of carbon* and the resulting values. The *social cost of carbon* is intended to be a comprehensive estimate of climate change damage but due to current limitations in integrated assessment models and data used, values may not include all important damage and are likely to underestimate the full damage from CO_2 emissions.

The carbon offset value is based on a market price for CO_2. Because this is an entirely voluntary market (such as the market for pearls or other non-essentials), the price is driven by marketing rather than true resource scarcity. With appropriate marketing, such as assurance of the protection of biodiversity, bird and fish reproduction, or other mangrove attributes, mangrove patrons could sell mangrove protection offsets at a much higher price than the current average CO_2 market price.

6.6.5 SUSTAINABILITY

Enjoying the benefits of carbon sequestration by mangroves does not damage the ecosystem. Other human uses of mangroves, however, do. The most recent information on the status of mangrove forest in Solomon Islands is from 2005 (FAO 2005). At that time, FAO reported that the rate of deforestation in Solomon Islands was four times higher than the average in the Pacific and that it had been increasing steadily from 1980 to 2005 (Table 30). This is alarming and suggests that if the rate does not drop substantially the mangrove forest area in Solomon Islands will be halved in about 40 years.

TABLE 30 • Loss of mangrove cover, 1980–2005

Region	Annual change/year 1980–1990		Annual change/year 1990–2000		Annual change/year 2000–2005	
	ha	%	ha	%	ha	%
Solomon Islands	-730	-1.3	-770	-1.6	-760	-1.70
Oceania	-9094	-0.42	-7865	-0.38	-7867	-0.39

Source: FAO (2005)

This rate of decline is alarming not just for carbon stocks, but also because mangroves provide a range of other ecosystem services such as provision of food and supporting services for the reproduction of juvenile fish (Warren-Rhodes et al. 2011). Losing mangroves in Solomon Islands is not just about carbon emissions, but is also an issue of food security.

6.6.6 DISTRIBUTION

Atmospheric carbon causing climate change is a global concern. There is no specific consumer and producer benefit, just a global benefit. The benefits of selling carbon offsets would accrue to the resource stewards, presumably local communities. There is also a consumer benefit to those who purchase carbon offsets, which is related to their *willingness-to-pay* for verification that carbon is being stored in natural sinks rather than released into the atmosphere.

6.7 RESEARCH, MANAGEMENT AND EDUCATION

6.7.1 IDENTIFY

Although recognition of the value of biodiversity has grown significantly in the past two decades (most notably by the creation of the United Nations CBD), biodiversity remains extremely difficult to quantify and value. One method to quantify the value of biodiversity is to evaluate the amount of public funds that are redistributed to help protect biodiverse areas. The unique biodiversity found in marine and coastal environments in the Pacific attracts investment in research and conservation from around the world. Furthermore, these biodiverse ecosystems offer education opportunities to students of all ages and investment from schools and universities. This interest in studying and protecting biodiversity attracts grants, scholarships and aid which benefit Pacific Island countries.

Domestic and international government expenditures represent a redistribution of resources, not a true *economic benefit*, but foreign aid contributes significantly to the economies of most Pacific Island countries. For example, MACBIO is funded by German tax *revenue*. The taxation may represent a cost or a benefit to German tax payers depending on whether or not they desire to pay for biodiversity conservation in the Pacific. For MACBIO countries, this redistribution is a benefit, although it should be noted that much of the expenditure goes to the salaries of foreign nationals working in the Pacific.

6.7.2 QUANTIFY

According to figures from the MDPAC, in 2013 there were more than 144 development projects in Solomon Islands, with a total budget of SI$ 901 million in Solomon Islands. It is possible to determine how much of this money is spent on environment and fisheries: MECDM projects accounted for SI$ 10.7 million while MFMR projects were worth SI$ 9.2 million. These figures account for only around 1% of the total development projects.

Presumably most of the fisheries aid is directed to marine ecosystems. All of the projects listed in Table 31 directly or indirectly related to fisheries. Given the nature of the projects, it is likely that most of them are focused on management of resources, with some minor contributions to education and research.

TABLE 31 • Foreign aid-funded projects of the Ministry of Fisheries and Marine Resources

Project	Project cost (SI$)
Tuna Loin Factories Project, Suva Bay and Tenaru	4,500,000
Wantok Project, Doma	1,000,000
Fish Aggregation Device Program	1,000,000
Provincial Fisheries Housing Project	1,000,000
Rehabilitation of Fisheries Centre	1,700,000
Total	9,200,000

There is no record of the proportion of MECDM funds allocated to marine and coastal and ecosystems. We assume that the minimum gross value of aid monies directed towards marine and coastal ecosystems is SI$ 9.2 million (US$ 1.2 million).

6.7.3 VALUE

There are costs associated with attracting and managing international aid that should be subtracted from the *gross revenue* to determine the true social benefit of these resources. To our knowledge, these costs have not been estimated. Because it is unknown how much of the MECDM funds are dedicated to marine and coastal ecosystems, we assume that only fisheries donor funds represent international investment in marine and coastal research, education, and management. We estimate that the value of research, education and management of marine and coastal ecosystems in Solomon Islands is at least SI$ 9.2 million (US$ 1.2 million). It is likely much higher than this, although administration costs would need to be subtracted in order to determine the true social benefit.

6.7.4 UNCERTAINTY

Although we have not subtracted the costs of attracting and administering these funds, we presume the gross amount, SI$ 9.2 million, is a considerable underestimate. Furthermore, government aid monies are just one stream of research and education funds. Many such funds may not come through the government budget. Researchers arriving from foreign institutions, for example, may bring benefits to Solomon Islands through their personal expenditure or employment of research assistants. These benefits are not included in the government budget *revenues*, but they are presumed to be relatively small in value.

6.7.5 SUSTAINABILITY

Research, education and management are largely non-extractive so can be considered sustainable. By and large, activities related to biodiversity research, education and management (such as the MACBIO project) are targeted towards scientific inquiry or sustainable resource management. Furthermore, research and education funds may depend on the presence of healthy ecosystems, therefore creating an incentive for sustainable management.

6.7.6 DISTRIBUTION

A persistent criticism of international aid is that a large proportion of the benefits return to citizens of the donor countries or consultants from other wealthy countries. While the number of aid dollars and in-kind assistance may be quite large, not all of this aid is of direct benefit to Solomon Islands.

6.8 OTHER VALUES

Below are examples of marine ecosystem services that may be found in Solomon Islands, but have not been analysed in detail in this study. Further research on this area will be needed to have a complete assessment of the benefits from marine ecosystems in Solomon Islands.

6.8.1 CULTURAL AND LIFESTYLE VALUES

Cultural values refer to the non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation and aesthetic experience (MEA 2005). This could include cultural heritage, traditional education, spiritual, religious or moral values, or the value of a sense of place.

The numbers of cultural traditions or events that involve or take place in marine ecosystems in Solomon Islands are countless and differ substantially among provinces. Turtles are hunted for feasts during cultural events in Isabel and in Western Province (McKeown 1977). In Owariki Island (Santa Catalina), during the Wogasia Festival, the inhabitants celebrate the end of the yam harvest by organising a simulated fight with spears which takes place on the beach of the island.

In Malaita, the harvesting of dolphins is important, as they add more value to shell money and can be used for solving tribal conflicts, bride price and even in exchange for food. Women are prohibited from accompanying or being seen with men during a dolphin-calling ritual. This spiritual belief helps the villages to harvest schools of dolphins. In Malaita, in particular, the making of jewellery from marine products is very important because of the tradition of *tafuli'ae* (bride price) — the family of the groom must present, as a gift, shell money commonly known as *tafuli'ae.* These are beautiful strands of shells with turtle spacers, each strand about 30 inches long, and usually made from four species of shells: *Chama pacifica, Beguina semiorbiculata, Anadara granosa* and *Atrina vexillum.*

During the headhunting days, people mostly lived in the mountains to avoid being raided but when Christianity was introduced to the islands and headhunting was abolished people started shifting to the coastal areas. This coastal drift influenced how communities interacted with marine resources. Most people live in a communal society where clans and tribes own land and marine resources communally. Thus, everyone is aware of the role they play in marine resource harvesting and this contributes to the social structure of communities. Throughout Solomon Islands, a common management practice is taboo areas that are marked for no fishing for a period and are opened when resources are needed for a village ceremony, death or feasting.

The traditional practices that have contributed to sustainable management of marine resources are slowly fading as traditional systems clash with modernity and globalisation. The increased pressure on marine resources is not only a result of increasing population, but also of the breakdown of traditional practices and customs.

6.8.2 BIO-PROSPECTING

Bio-prospecting is the process of discovering and commercialising new products from natural sources. Marine resources, particularly in areas with high biodiversity such as coral reefs or unique ecology such as deep-sea thermal vents, may have potentially marketable products or elements that could lead to marketable products.

Marine ecosystems of Solomon Islands have contributed to several medical discoveries (Dupré and Clua 2011):

- research on *Agelas mauritiana* (a sponge) enabled the discovery of the structure of new alkaloids with anti-malarial properties
- the sponge species *Theonella swinhoei* and *Coscinoderma mathewsi* contributed to the discovery of new metabolites with anti-inflammatory activity
- the sponge *Ptilocaulis spiculifer* contained new steroids with cytotoxic activity
- the sponge genus *Dysidea* contained substances with anti-malarial and other biological properties
- research on marine brown algae from Solomon Islands led to the discovery of active compounds with anti-inflammatory properties.

Although we cannot estimate the value of these discoveries, the importance of the field is unquestionable. Some of these substances could be used to develop new medicines that could be marketed around the world. One of the major issues of bio-prospecting is that often the countries where these discoveries are made do not benefit from them as big pharmaceutical companies rarely recognise and pay for their contribution.

The Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization is an international agreement which aims at sharing the benefits arising from the use of genetic resources in a fair and equitable way. If Solomon Islands, in the future, decides to ratify the protocol, the country could benefit from being part of a network of countries that are committing to manage bio-prospecting and the benefits that arise from it sustainably and equitably.

Subsistence fisheries in Solomon Islands are characterised by specialised knowledge handed down through generations.

6.8.3 BIOREMEDIATION

Mangroves and wetland estuaries filter and clean waste water. This ecosystem service is called bioremediation. In addition to providing habitat for inshore fisheries, protecting the coastline from erosion and sequestering carbon, mangroves play an important role in filtering polluted water. Mangroves areas around the main cities such as Honiara, Noro in Western Province and Auki in Malaita are likely to contribute to the filtration of waste water that is not treated before being discharged to rivers or the sea. In Fiji, a study estimated that the nutrient filtering services of mangrove soils yielded an average *present value* of US$ 192,723 per hectare over 50 years (Lal 1990). This value reflects the difference between the cost of a conventional sewage treatment plant (US$ 4.5 million) and use of mangroves for oxidation ponds (US$ 1.4 million). The average benefit of filtration by mangrove soils was estimated at US$ 10,556/ha/yr (Lal 1990).

6.8.4 HANDICRAFTS

Handicraft production is important in Solomon Islands. Households may produce handicrafts for commercial sale or for personal use. Marine ecosystems provide inputs for many different types of handicrafts. All variety of seashells are used to make traditional and contemporary jewellery. There is a large section of the market in Honiara dedicated to selling jewellery made of marine products from different provinces. In some cases, dolphin teeth, pearl shell and giant clam shells are used (Ross 1981).

Handicrafts that are sold earn vendors a *resource rent*, the same as any market good that depends on free natural inputs. The *resource rent* is the net value of the product after the value of labour time and other production costs have been subtracted. Handicrafts that are used at home have an avoided-cost value, meaning that they are worth what the household does not have to spend to purchase alternatives to these items.

6.8.5 WOOD HARVESTING

Mangrove trees are used for firewood, charcoal production, construction materials, wood chips and paper pulp. Mangrove wood can have a subsistence value when harvested and used by households or a producer and consumer market value if bought and sold.

Warren-Rhodes et al. (2011) studied the ecosystem services provided by mangroves in four provinces and found that the minimum annual subsistence value from mangroves was US$ 345–1501. Firewood and construction materials (for houses and boats) were the primary benefits received by communities. In all villages studied mangroves leaves, fruit, bark and roots were also used as medicinal remedies.

6.8.6 NON-USE, BEQUEST AND OPTION VALUES

Ecosystems can have value to people even if they do not directly receive benefits from the *ecosystem functions*. Individuals may simply appreciate knowing that ecosystems are healthy and that species are not going extinct. This is the *existence value* of ecosystems. Some individuals may also want to maintain options for future uses of the marine environment (*option value*) or preserve ecosystems so that they are available for future generations (*bequest value*).

Existence value, *option value* and *bequest value* of ecosystems are non-market ecosystem services. The absence of these values in markets or economies can lead to poor resource management decisions (Cesar et al. 2003). Since there are no markets for these services nor any associated markets that can reveal their value, the only way to estimate their value is to simply ask people what they are worth, using *stated preference* economic survey methods. Determining the value of an ecosystem service by asking what individuals would be willing to pay for its presence or maintenance is called *contingent valuation*. Asking individuals to make hypothetical trade-offs between different ecosystem services is called *choice modelling*. Both methods ask individuals, via surveys or interviews, to state their preference for the non-market ecosystem service either in monetary terms or in terms of willingness-to-trade other goods or services for the non-market ecosystem service in question.

Although difficult to measure, *existence*, *bequest* and *option values* are a component of the *total economic value* of an ecosystem. A single individual may only be willing to pay a very small amount for the existence of an option for future use of a resource, but the sum of *willingness-to-pay* across many thousands of individuals may still represent considerable *economic value* (Daubert and Young 1981; Loomis et al. 2000). It is beyond the scope of MACBIO to conduct stated preference surveys to elicit data about non-use benefits of marine and coastal ecosystems in Solomon Islands. However, non-use ecosystem service values have been studied in Fiji (O'Garra 2007). In the Navakavu Locally Managed Marine Area in Fiji, residents were willing to contribute a mean 3.03 hours of their time (worth US$ 6.15–11.83 per month per individual) or donate an average of US$ 4.78 per individual per month (US$ 57.45 per individual per year) to conserve their traditional fishing grounds. This value is an option or *bequest value*. Although the *nominal* values per individual may seem small, note that the average monthly household income for local residents was US$ 174.94. Therefore, individuals' mean *willingness-to-pay* to conserve this marine resource represented 2.7% of their income (O'Garra 2007).

6.8.7 SUPPORTING SERVICES: ECOLOGICAL PROCESSES AND BIOLOGICAL DIVERSITY

Some *ecosystem functions* do not directly benefit humans, but may be instrumental in supporting other *ecosystem functions*. Basic *ecosystem functions* such as photosynthesis, nutrient cycling, soil and sand formation and other so-called *supporting ecosystem services* are intermediate services to many human behaviours and activities. The ocean has an important role in the production of oxygen (phytoplankton produce half of the earth's oxygen), nitrogen fixation, waste assimilation, and regulating global temperatures and climate (Samonte-Tan et al. 2010: Galland et al. 2012; NOAA 2012). While some of these *ecosystem functions* may not benefit humans directly, they underpin life on earth. None of the ecosystem services identified in this report can exist without well-functioning ecological processes (such as production, growth, recruitment) underpinned by biological and abiotic diversity of marine ecosystems (MEA 2005). The value of ecological processes and the underpinning marine diversity is, however, carried over into direct or final *ecosystem service valuation*s. To avoid double-counting the value of *supporting ecosystem services*, *ecosystem service valuation* should focus on the final human benefits coming from the end-products of *ecosystem functions* (Boyd and Banzhaf 2007; Fisher et al. 2009).

7. DISCUSSION

Solomon Islands, characterised by its large number of islands and its vast EEZ, has an extremely important relationship with the ocean and its coasts. This is not limited to the benefits that the country receives from the different types of fisheries, but also from coastal protection, carbon sequestration and tourism, among other benefits. Some uses of ecosystem services have been unsustainable, such as the export of *bêche-de-mer* and trochus. Other services, such as tourism and aquarium trade, could support larger human benefits without depleting the nation's stores of natural capital.

7.1 SYNTHESIS OF RESULTS

Although the study presents figures for the value of ecosystem services, a number of uncertainties and caveats should be applied to the interpretation of the valuation of each ecosystem service (Chapter 9). This section summarises the valuation of the seven ecosystem services examined. For more detailed information about each ecosystem service, see Chapter 6.

Subsistence fisheries — Inshore subsistence fisheries are valued at SI$ 442 million/year (~US$ 56 million/year) which corresponds to SI$ 857/year (~US$ 114/year) per person and is equivalent to 5% of the *nominal* Solomon Islands GDP. These results are based on the 2009 Census (SINSO 2009) and PROCFish data (Pinca et al. 2006). Our estimates of subsistence fish catch are 48% higher than previous estimates by Gillett (2009).

Commercial inshore fisheries — Commercial inshore fisheries are valued at a total of SI$ 70 million/year (~US$9.32 million/year), which corresponds to SI$ 156/year (~US$ 21/year) per person and 0.8% of the *nominal* GDP of Solomon Islands. These results are based on the 2009 Census (SINSO 2009) and PROCFish data (Pinca et al. 2006) and are more than four times higher than previous estimates by Gillett and Lightfoot (2001).

Many parts of inshore subsistence and commercial fisheries target the same species, with some exceptions. For example, commercial fisheries target *bêche-de-mer*, trochus and aquarium fish as well as inshore reef fish. Despite potential uncertainty, the results highlight that inshore artisanal subsistence and commercial fisheries in Solomon Islands may be more important to the livelihoods and wellbeing of Solomon Islanders than previously thought. There are concerns regarding the sustainability of inshore fisheries, although pressures on marine resources vary greatly among provinces. Pressure on marine resources in the commercial artisanal fishery is higher in more densely populated provinces such as Guadalcanal and Malaita, while fishing pressure is lower in Temotu and Isabel.

Our findings suggest two contrasting policy approaches: a) the government could facilitate the sale of fish from the less heavily fished provinces such as Choiseul and Isabel to the more heavily fished provinces such as Guadalcanal and Malaita to decrease fishing pressure in these provinces. However, this could create a perverse effect by encouraging less sustainable fishing in areas where there is currently less fishing pressure; b) the government could strengthen sustainable management practices in provinces where there is high pressure on fisheries instead, and encourage tourism in less exploited provinces.

Bêche-de-mer — *Bêche-de-mer* exports from 1999 to 2010 varied widely but averaged SI$ 3.34 million/year (~US$ 446,000/year). Catches have been decreasing steadily for the past 40 years.

Trochus — Trochus exports from 1999 to 2010 averaged SI$ 2.13 million/year (~US$ 284,250/year). Catches have been decreasing steadily for the past 50 years.

Both the *bêche-de-mer* and trochus fisheries are overexploited and not sustainably managed. They are important ecosystem services for Solomon Islanders because they can provide useful and easy cash income to coastal communities. We suggest maintaining the moratorium on the *bêche-de-mer* fishery until biological surveys show a substantial and long-term increase in stocks. Controls should be strengthened as illegal fishing and exports are likely. We also suggest introducing a moratorium on the trochus fishery until the stock recovers.

Aquarium trade — Aquarium trade exports from 1999 to 2010 averaged SI$ 1.22 million/year (~US$ 162,520/year). Currently, this fishery is not of concern. We suggest introducing management practices to avoid targeting juveniles and particularly vulnerable species. Control over the use of destructive fishing practices should be strengthened.

Commercial offshore fisheries — Commercial offshore fisheries are valued at SI$ 1,660 million/year (~US$ 221 million/year) and target tuna almost exclusively. There are concerns regarding the sustainability of this fishery because most the operating vessels are purse seiners and only a handful of vessels use the more sustainable pole and line technique. A problem with this fishery is that most of the benefits accrue outside Solomon Islands; 99% of boats are not from Solomon Islands and most of the tuna is sold abroad. We suggest that the government enforce the existing VDS scheme and start to market pole and line tuna as a sustainably produced product. Currently only 1% of the boats use pole and line and all are from Solomon Islands. Current government policies encourage value-adding activities in Solomon Islands to retain more of the tuna value locally.

Minerals and aggregate — Aggregate mining on beaches is not common in Solomon Islands. Most of these activities are conducted in rivers that are beyond the scope of this report. There is increasing interest in deep-sea mining. To date Solomon Islands has only issued exploration licenses yielding *revenue* for the government of SI$ 2.74 million in 2012 (~US$ 364,000) and SI$ 998,217 (~US$ 132,962) in 2013. Given the importance of marine ecosystems for Solomon Islanders, and the potential negative impacts of mining activities, the government should consider environmental risks carefully before any mining licences are issued.

Tourism — Tourism expenditure from foreign visitors amounts to SI$ 516 million/year (~US$ 68 million/year). According to a preliminary survey designed to estimate the contribution of marine ecosystem services to the tourism sector, 22% of the expenditure or SI$ 118 million/year (~US$ 15 million/year) is related to marine ecosystems. Currently the sustainability of tourism is not of concern. In fact, tourism should be considered an incentive to preserve marine ecosystems. We support the current policy of the MCT to encourage sustainable local tourism.

Coastal protection — The value of coastal protection provided by coral reefs against damage from cyclone storm surges in Guadalcanal is estimated to be in the range SI$ 25–42 million/year (~US$ 3.3–5.6 million). The estimated value of this ecosystem service is highly uncertain and should be treated with caution. The scope of this assessment is restricted to only one aspect of coastal protection and to a limited geographic area (Guadalcanal). The full value of this ecosystem service for Solomon Islands is likely to be considerably higher.

Carbon sequestration — Carbon sequestration is worth at least SI$ 161.9 million/year US$ 21.6 million/year) measured by the *social cost of carbon*. The potential *revenue* from the sale of carbon offsets for the protection of stored carbon in mangroves is estimated to be in the range of SI$ 55.059 – 72.763 million (US$ 7.333 – US$ 9.692 million) in offsets each year. Mangrove areas, however, are decreasing at an alarming rate (1.7%/year). The need to strengthen the conservation of these resources is even more urgent because mangroves provide a wide range of ecosystem services essential for Solomon Islanders. Introducing payments for ecosystem services such as REDD+ or carbon offsets may be a good incentive to decrease deforestation rates.

Research, education and management — The value of research, education and management services is one of the hardest to estimate. Domestic government expenditure on research or management projects should be considered as a redistribution of resources, therefore not an *economic benefit*, while foreign aid can be considered an additional benefit to the Solomon Islands economy. The MFMR received SI$ 9.2 million in 2013 that, with some caveats, can be considered the value of this ecosystem service.

8. RECOMMENDATIONS AND SUGGESTIONS

8.1 FUTURE VALUATIONS

This report should be considered a first step towards a more complete and robust ecosystem services valuation. The analysis has relied mainly on existing data, not only due to resource constraints, but also because one of the objectives was to identify data gaps that could be addressed by future projects or studies. This section provides some suggestions to improve data collection for future ecosystem services valuations.

Firstly, it is important to clarify that ecosystem services valuation does not necessarily require one-off data collection exercises targeted to address specific and unique policy questions each time. This could be expensive and time consuming and it risks making the analysis an isolated exercise with few links to other economic studies and government processes. Currently the SINSO conducts a Census (the most recent in 2009) and a Household Income and Expenditure Survey (HIES) (the most recent in 2005) that provided detailed and robust estimates for a large number of socioeconomic variables. Future censuses and HIES could either reformulate old questions or include new questions that would help environmental economists to conduct more precise ecosystem services valuation not just for marine and coastal services, but also for ecosystem services from terrestrial and freshwater ecosystems.

For example, simple questions regarding catch per unit time for inshore subsistence and commercial fisheries would substantially improve the quality of the data. Existing data are unreliable, especially given the large discrepancies with previous valuations. More general questions regarding the harvest of natural resources (wood, aggregates, fish, invertebrates, game etc.) would help to quantify a wide set of ecosystem services at the national scale without having to conduct dedicated ecosystem valuation surveys.

Future valuations could be improved by increasing data accessibility. While confidentiality is required in a minority of cases, the majority of data should be available to government ministries, civil society and public. This would facilitate the work of officials and researchers leading to better ecosystem services valuation that could benefit government decision-making processes.

The MACBIO project provides an overview of a range of important marine ecosystem services and assesses the current state of knowledge and data gaps. Future studies, however, should focus on valuation of specific ecosystem services, based on the information provided here. These would be simpler to conduct and more helpful for policy-making. Focusing on specific services can accommodate time and resource constraints, but also allows greater flexibility in evaluation methods, data collection and reporting.

Specific and periodical ecosystem services valuation is fundamental in cases where marine resources are unsustainably managed such as the *bêche-de-mer* and trochus fisheries and some aspects of the tuna fishery, so that management interventions can be tailored with up-to-date information. When should a fishery ban be introduced? When it should be lifted? How many exports should the government allow given the current market price and the status of the resource? These are all questions that can only be answered successfully with constant monitoring. The benefit of regular monitoring is that once the valuation methods are established and the staff trained, the additional costs of conducting such an assessment are minimal.

8.2 HOW TO USE THIS REPORT

In Chapter 6 and more briefly in Section 7.1, we provide policy suggestions based on the results of the *ecosystem service valuation*. Tables throughout the report offer detailed values disaggregated by province, as the objective of the report was to provide information as useful as possible for policy-makers. These data could be useful not only for national and provincial governments, but also for other stakeholders such as the private sector, international organisations and civil society.

This report can be used in many different ways and the applications of the results differ widely. Information on catch of fisheries per hectare of reef provides useful information on the sustainability of that ecosystem service and could inform conservation strategies and prioritisation of areas for intervention. The benefit of having information not just on catches, but also on their value per household, is that the costs of a ban on a certain type of fisheries are known and could aid in designing interventions to mitigate this loss. Data on the concentration of mangroves per kilometre of coast could be useful for private organisations or NGOs that are interested in setting up payment for ecosystem services and would like to find the province where there are more mangrove forests.

Another important potential application of ecosystem services in Solomon Islands is for calculating compensation. In many cases of acquisition of land (including coastal land) for public purposes or private projects, disagreement over compensation has posed a serious problem for policy-makers and local institutions. Ecosystem services valuation could be used as a transparent methodology to quantify some of the benefits that the owner of land might lose and might be a basis by which to identify a fact-based level compensation. Such information could be helpful for any private citizen involved in a land dispute, but also for the LALSU which is the office delegated to deal with such issues in Solomon Islands.

The commercial sector could benefit from the results of this ecosystem services valuation. In the case of the inshore commercial fishery, the value of this ecosystem service per person and per hectare of reef differs widely from province to province. This could provide useful information that could aid decision-making about whether to facilitate or subsidise shipping routes from provinces where fishery pressure is lower to more densely populated areas where overfishing is a concern. An additional advantage of having access to data on the benefit that specific types of fisheries bring to Solomon Islanders is the possible enhancement of international commerce policies. For instance, if the price of a certain resource increases on international markets, the government could decide to limit exports for that type of product to limit fishing pressure in that year without altering the benefit to households from that ecosystem service.

The last and probably most important use of ecosystem services valuation is advocacy. Being able to demonstrate and quantify the benefits received from Solomon Islands marine ecosystems is a very strong argument for more sustainable use of the ocean and its resources. Putting a monetary value on nature is controversial, but has the strong benefit of translating the value of nature and conservation into terms familiar to policy-makers.

9. CAVEATS AND CONSIDERATIONS

In general, ecosystem services valuations are subject to a substantial degree of uncertainty. Chapter 6 describes the uncertainties related to the methods and results of each ecosystem service. These uncertainties should be taken into account when decisions are made.

The benefits quantified and valued in this report should be considered individually. Policy-makers should resist the urge to aggregate these values because:

- Each value represents a slightly different type of benefit. Gross values, net values, employment, government *revenue* and *consumer surplus* are all different units for measuring benefits and should not be combined together, despite the fact that they are all represented in SI$.
- Values represent current use, not sustainable use, equitable use or maximum potential benefit. Some ecosystem services may be unsustainable at current rates of exploitation, while other could be expanded greatly.
- Some services complement, others compete. For instance, growth in the aquarium trade may adversely impact the inshore finfish and invertebrate fishery, whereas protection of mangrove areas may increase coastal protection, carbon sequestration and inshore fisheries productivity.

The information in Chapter 6 allows us to better understand the human benefits of Solomon Islands' marine and coastal environment. Although values and quantities should not be added together, they can and should be used to compare the types and magnitude of benefits coming from different marine resources. For example, *bêche-de-mer*, trochus exports and the aquarium trade are services of comparable orders of magnitude, but it is important to note that the benefits accrue to very different groups. Other comparisons, such as between subsistence fisheries and *bêche-de-mer* exports, are more problematic or may even be incorrect. The first takes into account costs of fisheries, while the second only the value of exports.

Finally, we recommend referring to the **Quantify** and **Uncertainty** sections in Chapter 6 for specific qualifications regarding each *ecosystem service valuation*. This is important for a clear understanding of the meaning and limitations of the values obtained in this analysis.

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12. APPENDIX I GLOSSARY

Avoided damage cost valuation method: A cost-based valuation technique that estimates the value of an ecosystem service by calculating the damage that is avoided to infrastructure, property and people by the presence of ecosystems.

Baseline: The starting point from which the impact of a policy or investment is assessed. In the context of ecosystem service valuation, the baseline is a description of the level of ecosystem service provision before a policy or investment intervention.

Beneficiary: A person that benefits from the provision of ecosystem system services.

Bequest value: the value to the current generation of knowing that something (e.g. pristine coral reef) will be available to future generations.

Constant prices: Prices that have been adjusted to the price level in a specific year. Constant prices account for inflation and allow values to be compared across different time periods.

Consumer surplus: The difference between what consumers are willing to pay for a good and its price. Consumer surplus is a measure of the benefit that consumers derive from the consumption of a good or service over and above the price they have paid for it.

Cost-benefit analysis: An evaluation method that assesses the economic efficiency of policies, projects or investments by comparing their costs and benefits in present value terms. This type of analysis may include both market and non-market values and accounts for opportunity costs.

Direct use value: The value derived from direct use of an ecosystem, including provisioning and recreational ecosystem services. Use can be consumptive (e.g. fish for food) or non-consumptive (e.g viewing reef fish).

Discount rate: The rate used to determine the present value of a stream of future costs and benefits. The discount rate reflects individuals' or society's time preference and/or the productive use of capital.

Discounting: The process of calculating the present value of a stream of future values (benefits or costs). Discounting reflects individuals' or society's time preference and/or the productive use of capital. The formula for discounting or calculating present value is: present value = future value/$(1+r)^n$, where r is the discount rate and n is the number of years in the future in which the cost or benefit occurs.

Economic activity analysis: An analysis that tracks the flow of dollars spent within a region (market values). Both economic impact and economic contribution analysis are types of economic activity analysis.

Economic activity: The production and consumption of goods and services. Economic activity is conventionally measured in monetary terms as the amount of money spent or earned and may include 'multiplier effects' of input costs and wages

Economic benefit: the net increase in social welfare. Economic benefits include both market and non-market values, producer and consumer benefits. Economic benefit refers to a positive change in human wellbeing.

Economic contribution: The gross change in economic activity associated with an industry, event, or policy in an existing regional economy.

Economic cost: A negative change in human wellbeing.

Economic impact: The net changes in new economic activity associated with an industry, event, or policy in an existing regional economy. It may be positive or negative.

Economic value: i) The monetary measure of the wellbeing associated with the production and consumption of goods and services, including ecosystem services. Economic value is comprised of producer and consumer surplus and is usually described in monetary terms. Or ii) The contribution of an action or object to human wellbeing (social welfare).

Ecosystem contribution factor: The degree of association between marine and coastal ecosystems and different tourist activities.

Ecosystem functions: The biological, geochemical and physical processes and components that take place or occur within an ecosystem.

Ecosystem service approach: A framework for analysing how human welfare is affected by the condition of the natural environment.

Ecosystem service valuation: Calculation, scientific and mathematic, of the net human benefits of an ecosystem service, usually in monetary units.

Ecosystem services: The benefits that ecosystems provide to people. This includes services (e.g. coastal protection) and goods (e.g. fish).

Ecosystem: A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit.

Evaluate: To assess the overall effect of a policy or investment.

Evaluation: The assessment of the overall impact of a policy or investment. Evaluations can be conducted before or after implementation of a policy or investment.

Existence value: The value that people attach to the continued existence of an ecosystem good or service, unrelated to any current or potential future use.

Factor cost: Total cost of all factors of production consumed or used in producing a good or service.

Financial benefit: A receipt of money to a government, firm, household or individual.

Financial cost: A debit of money from a government, firm, household or individual.

Free-on-board: The taxable value for each fished species. This value theoretically represents the market value of the product, although this is not always the case in practice.

Future value: A value that occurs in future time periods. See also present value.

Geographic Information Systems (GIS): An information system that captures, stores, manages, analyses and presents data that is linked to a geographic location.

Green accounting: The inclusion of information on environmental goods and services and/or natural capital in national, sectoral or business accounts.

Gross revenue: Money income that a firm receives from the sale of goods or services without deduction of the costs of producing those goods or services. Gross revenue from the sale of a good or service is computed as the price of the good (or service) multiplied by the quantity sold.

Indirect use value: The value of ecosystems services that contribute to human welfare without direct contact with the elements of the ecosystem, for example regulating services such as plants producing oxygen or coral reefs providing coastal protection.

Inflation: A general rise in prices in an economy.

Instrumental value: The importance of something as a means to providing something else that is of value. For example, a coral reef may have instrumental value in reducing risk to human life from extreme storm events.

Intermediate costs: The costs of inputs or intermediate goods that are used in the production of final consumption goods. For example, the cost of fishing gear used to catch fish is an intermediate cost to the harvest and sale of fish.

Intrinsic value: The value of something in and for itself, irrespective of its utility to something or someone else. Not related to human interests and therefore cannot be measured with economic methods.

Marginal value: The incremental change in value of an ecosystem service resulting from an incremental change (one additional unit) in the quantity produced or consumed.

Negative externality: NEGATIVE EXTERNALITIES occur when the consumption or production of a good causes a harmful effect to a third party.

Net revenue: Monetary income (revenue) that a firm receives from the sale of goods and services with deduction of the costs of producing those goods and services. Net revenue from the sale of a good is computed as the price of the good multiplied by the quantity sold, minus the cost of production.

Nominal: The term 'nominal' indicates that a reported value includes the effect of inflation. Prices, values, revenues etc. reported in 'nominal' terms cannot be compared directly across different time periods. See also real and constant prices.

Non-use value: The value that people gain from an ecosystem that is not based on the direct or indirect use of the resource. Non-use values may include existence values, bequest values and altruistic values.

Opportunity cost: The value to the economy of a good, service or resource in its next best alternative use.

Option value: The premium placed on maintaining environmental or natural resources for possible future uses, over and above the direct or indirect value of these uses.

Present value: A value that occurs in the present time period. Present values for costs and benefits that occur in the future can be computed through the process of discounting (see discount rate). Expressing all values (present and future) in present value terms allows them to be directly compared by accounting for society's time preferences.

Producer surplus: The amount that producers benefit by selling at a market price that is higher than the minimum price that they would be willing to sell for. Producer surplus is computed as the difference between the cost of production and the market price.

Profit: The difference between the revenue received by a firm and the costs incurred in the production of goods and services (see also producer surplus).

Purchasing power parity adjusted exchange rate: An exchange rate that equalises the purchasing power of two currencies in their home countries for a given basket of goods.

Purchasing power parity: An indicator of price level differences across countries. Figures represented in purchasing power parity represent the relative purchasing power of money in the given country, accounting for variance in the price of goods. Typically presented relative to the purchasing power of US dollars in the United States.

Real: The term 'real' indicates that a reported value excludes or controls for the effect of inflation (synonymous with constant prices). Reporting prices, values, revenues etc. in 'real' terms allows them to be compared directly across different time periods. See also nominal and constant prices.

Regulating services: A category of ecosystem services that refers to the benefits obtained from the regulation of ecosystem processes. Examples include water flow regulation, carbon sequestration and nutrient cycling.

Rent: Any payment for a factor of production in excess of the amount needed to bring that factor into production (see also producer surplus and resource rent).

Replacement cost method: A valuation technique that estimates the value of an ecosystem service by calculating the cost of human-constructed infrastructure that would provide same or similar service to the natural ecosystem. Common examples are sea walls and wastewater treatment plants that provide similar services to reefs, mangroves, and wetland ecosystems.

Resource rent: The difference between the total revenue generated from the extraction of a natural resource and all costs incurred during the extraction process (see also producer surplus). Refers to profit obtained by individuals or firms because they have unique access to a natural resource.

Revenue: Money income that a firm receives from the sale of goods and services (often used synonymously with gross revenue).

Social cost of carbon: The social cost of carbon is an estimate of the economic damages associated with a small increase in carbon dioxide (CO_2) emissions, conventionally one tonne, in a given year. This dollar figure also represents the value of damages avoided for a small emission reduction (i.e. the benefit of a CO_2 reduction).

Supporting ecosystem services: A category of ecosystem services that are necessary for the production of all other ecosystem services. Examples include nutrient cycling, soil formation and primary production (photosynthesis).

Total economic value: i) All marketed and non-marketed benefits (ecosystem services) derived from any ecosystem, including direct, indirect, option and non-use values, or ii) The total value to all beneficiaries (consumer, producer, government, local, foreign) from any ecosystem service.

Use value: Economic value derived from the human use of an ecosystem. It is the sum of direct use, indirect use and option values.

User cost: The cost incurred over a period of time by the owner of a fixed asset as a consequence of using it to provide a flow of capital or consumption services; the implications of current consumption decisions on future opportunity. User cost is the depreciation on the asset resulting from its use.

Utilitarian value: A measure of human welfare or satisfaction. Synonymous with economic value.

Valuation: The process or practice of estimating human benefits of ecosystem services or costs of damages to ecosystem services, represented in monetary units.

Value: The contribution of an action or object to human wellbeing (social welfare).

Value-added: The difference between cost of inputs and the price of the produced good or service. Value-added can be computed for intermediate and final goods and services.

Welfare: An individual's satisfaction of their wants and needs. The human satisfaction or utility generated from a good or service.

Willingness-to-accept: The minimum amount of money an individual requires as compensation in order to forego a good or service.

Willingness-to-pay: The maximum amount of money an individual would pay in order to obtain a good, service, or avoid a change in condition.

13. APPENDIX II STAKEHOLDER CONSULTATIONS, ATTENDEE LISTS

9–12 OCTOBER 2013

The first MACBIO mission to Solomon Islands was 9–12 October 2013. The MACBIO team that went on the trip included: Dr Jan H Steffen (GIZ), Dr Sangeeta Mangubai (IUCN), Alan Saunders (IUCN) and Riibeta Abeta (GIZ). The purpose was to consult with government ministries and introduce the MACBIO project and its three main components including ecosystem service valuation.

Dr Melchior Mataki	Permanent Secretary, Ministry of Environment, Climate Change, Disaster and Meteorology
Ms Agnetha Vave-Karamui	Director, Environment Conservation Division
Mr James Teri	Director, Ministry of Fisheries and Marine Resources
Ms Duta Kauhiona	Ministry of Fisheries and Marine Resources
Mr Peter Kenilorea	Ministry of Fisheries and Marine Resources
Ms Lysa Wini	Environment Conservation Division /Coral Triangle Initiative
Ms Susan Dhari	Chief Planning Officer, Ministry of Planning
Mr Barnabas Bago	Chief Planning Officer, Ministry of Planning
Mr Haikiu Baiabe	Live and Learn Solomon Islands
Ms Delvene Boso	WorldFish
Ms Julie Lloyd	Solomon Islands Local Marine Managed Areas
Ms Elirose Fagaqweka	Solomon Islands Local Marine Managed Areas
Mr Willie Atu	Programme Manager, The Nature Conservancy
Mr Greg Tai'eha	East Rennell World Heritage Site
Mr Maurice Knight	Coral Triangle Initiative, Coral Triangle Support Partnership
Mr Chanel Iroi	Secretary of Ministry of Environment, Climate Change, Disaster and Meteorology
Mr Tia Masolo	Environment Conservation Division
	Environment Conservation Division

14 AUGUST 2014

A follow-up TEEB workshop was held in Solomon Islands on 14 August 2014. Participants were:

Mr Matthew Walekoro	Ministry of Development Planning and Aid Coordination
Ms Savita Nandan	Ministry of Culture and Tourism
Mr Barnabas Bago	Ministry of Development Planning and Aid Coordination
Ms Agnetha Vave-Karamui	Environment and Conservation Division – Ministry of Environment, Climate Change, Disaster Management & Meteorology
Ms Rosalie Masu	Ministry of Fisheries and Marine Resources
Ms Rieka Kwalai	Ministry of Fisheries and Marine Resources

Ms Sophia Natu	Ministry of Fisheries and Marine Resources
Ms Ronnelle Panda	Ministry of Fisheries and Marine Resources
Ms Senoveva Mauli	The Nature Conservancy
Mr Kellington Simeon	Pacific Horizons Consultancy Group Ltd
Ms Elizabeth Cotterell	Environment and Conservation Division, Ministry of Environment, Climate Change, Disaster Management and Meteorology
Ms Dura Bero Kauhiona	Expanding Reach of community based marine resource management in Solomon Islands (ERSI) Project – Ministry of Fisheries and Marine Resources,
Mr Peter Ramohia	ADB Coral Triangle Pacific Project
Mr John Legata	Ministry of Fisheries and Marine Resources
Mr Mark Ligo	Ministry of Culture and Tourism
Mr Josefa Tuamoto	Solomon Islands Visitors Bureau
Mr Niniu Oligao	Solomon Islands Tourism for Inclusive Development Project Ministry of Culture and Tourism
Mr Willie Atu	The Nature Conservancy
Ms Delvene Boso	The WorldFish
Mr Gregory Auta'a	Tourism Division, Ministry of Culture and Tourism
Mr Douglas Kimi	Solomon Islands National Statistics Office (SINSO), Ministry of Finance and Treasury,

12–15 AUGUST 2014

Dr Leanne Fernandes, Senior Project Advisor, MACBIO, Fei Tevi, Leadership, Green Growth and Sustainability Initiative project and Hans Wendt, Technical Officer, GIS, MACBIO visited Honiara on 12–15 August, 2014. The purpose of the trip was for Dr Fernandes to meet key players for MACBIO in Solomon Islands, introduced by Fei Tevi; and for Mr Wendt to meet relevant staff working with spatial data, introduced by Lysa Wini. Listed below are the various government and organisational representatives with whom the MACBIO team met:

Mr Jerry Manele	Permanent Secretary, Ministry of Development Planning and Aid Coordination
Mr Steve Lindsay	Mekem Strong Solomon Islands Fisheries, Inshore Fisheries Advisor to the Ministry of Marine Resources and Fisheries,
Mr Charles Fono	Ministry of Development Planning and Aid Coordination
Mr Barnabas Bago	Ministry of Development Planning and Aid Coordination
Dr Christian Ramofafia	Permanent Secretary, Ministry of Fisheries and Marine Resources
Dr Philip Tagini	Senior Political Advisor, Prime Minister
Mr John Wasi	Permanent Secretary, Ministry of Tourism
Ms Lyn Legua	Director Planning, Ministry of Development, Planning and Aid Coordination
Mr Travis Ziku	Planning, Ministry of Development Planning and Aid Coordination
Dr Melchior Mataki	Permanent Secretary, Ministry of Environment, Climate Change, Disaster Management and Meteorology
Ms Senoveva Mauli	Director, Solomon Islands Community Conservation Program
Mr David Boseto	Board Member, Solomon Islands Community Conservation Program
Mr Willie Atu	Country Director, The Nature Conservancy, Solomon Islands
Ms Agnetha Vave-Karamui	Chief Conservation Officer, Ministry of Environment, Climate Change, Disaster Management and Meteorology. MACBIO National Counterpart

Ms Elizabeth Cotterell	Protected Areas Advisor, Ministry of Environment, Climate Change, Disaster Management and Meteorology
Mr Trevor Maeda	Senior Conservation Officer, Ministry of Environment, Climate Change, Disaster Management and Meteorology
Ms Lysa Wini	IUCN Project Liaison Officer, Solomon Islands
Mr Reginald Ruben	Principal GIS Officer, Risk Resilience Development Focal Point, Ministry of Environment, Climate Change, Disaster Management and Meteorology
Mr Bryan Pitakia	GIS Consultant
Ms Rosemary Apa	Chief Environment Officer, Ministry of Environment, Climate Change, Disaster Management and Meteorology
Mr Peter Kenilorea	Senior Fisheries Officer, Solomon Islands Locally Managed Marine Areas Network
Mr James Teri	Director of Fisheries, Ministry of Fisheries and Marine Resources
Ms Rosalie Masu	Deputy Director—Inshore Fisheries, Ministry of Fisheries and Marine Resources
Mr Dalton Hone	Chief Cartographer, GIS and mapping section, Ministry of Lands, Housing and Survey
Mr Nate Peterson	GIS and Conservation Information Manager, The Nature Conservancy

9–13 FEBRUARY 2015

On 9–13 February 2015 Dr Leanne Fernandes, Senior Project Advisor (MACBIO) and Mr Jacob Salcone, MACBIO Technical Officer —TEEB conducted a workshop and presented key findings of the marine ecosystem services valuation (MESV) report for Solomon Islands. Participants were:

Mr Matthew Walekoro	Ministry of Planning and Aid Coordination
Mr Collin Gereniu	The Nature Conservancy
Mr Rieka Kwalai	Ministry of Fisheries and Marine Resources
Mr Charles Tobasala	Ministry of Fisheries and Marine Resources
Ms Duta Bero Kauihina	Ministry of Fisheries and Marine Resources
Mr Alex Meloty	Ministry of Fisheries and Marine Resources
Mr Hefford Panapio	Ministry of Mines, Energy and Rural Electrification
Mr Laurie Leketo	Ministry of Culture and Tourism
Mr Fred S Patteson	Secretariat of the Pacific Regional Environment Programme
Mr Jimmy Kereseka	The Nature Conservancy
Ms Simone Retif	Department of Environment
Mr Tim Skewes	Commonwealth Scientific and Industrial Research Organisation
Ms Ivory Akao	Ministry of Fisheries and Marine Resources
Ms Agnetha Vave-Karamui	Ministry of Environment, Climate Change, Disaster Management and Meteorology
Mr Willie Atu	The Nature Conservancy
Ms Senoveva Mauli	Solomon Islands Community Conservation Partnerships
Mr Peter Kenilorea	Ministry of Fisheries and Marine Resources
Ms Rosalie Masu	Ministry of Fisheries and Marine Resources

Mr Sylvester Diake	Ministry of Fisheries and Marine Resources
Mr Allen Kisi Ofea	Ministry of Environment, Climate Change, Disaster Management and Meteorology
Dr Reuben Sulu	WorldFish
Mr Steve Lindsay	Inshore Fisheries Advisor to the Ministry of Fisheries and Marine Resources, New Zealand Aid Programme
Mr Simon Diffy	New Zealand Aid Programme
Dr Melchior Mataki	Permanent Secretary, Ministry of Environment, Climate Change, Disaster Management and Meteorology
Mr Roy Mae	Under-Secretary, Ministry of Development Planning and Aid Coordination

Individual meetings were also held with:

Ms Agnetha Vave-Karamui	Chief Conservation Officer, Ministry of Environment, Climate Change, Disaster Management and Meteorology. MACBIO National Counterpart
Ms Lysa Wini-Simeon	IUCN Project Liaison Officer, Solomon Islands
Mr Rence Sore	Special Secretary to the Prime Minister, Office of the Prime Minister and Cabinet
Captain Brian Aonima	Deputy Director, Solomon Islands Maritime Authority, Ministry of Infrastructure and Development
Dr Chris Reid	Fisheries economist, Fisheries Forum Agency
Dr Reuben Sulu	WorldFish
Mr Willie Atu	Country Director, The Nature Conservancy
Mr Jeffery Kauha	Permanent Secretary, Ministry of Mines, Energy and Rural Electrification
Mr John Wasi	Permanent Secretary, Ministry of Culture and Tourism
Mr Barney Sivoro	Director, Tourism
Dr Christian Ramofafia	Permanent Secretary, Ministry of Fisheries and Marine Resources
Ms Rosalie Masu	Deputy Director, Inshore Fisheries, Ministry of Fisheries and Marine Resources
Mr Ian Freeman	Fisheries Management Advisor, Fisheries Forum Agency
Ms Alice McDonald	Fisheries Management Advisor, Fisheries Forum Agency

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